Appendix 8-6

Certificate of completion of the pilot site

Inspection Certificate

(Passed)

1. Name of Consulting Service Assignment	The Pilot Project for Landslide and Rock fall mitigation works (Lot 1) under the Technical Cooperation for Landslide Mitigation Project
2. Performance Period	28/01/2016 – 28/07/2018
3. Contract Amount	LKR 38,268,930.00 (Final confirmed price: LKR 37,361,900.36)
4. Name of Contractor	ELS Construction (Pvt) Ltd
5. Progress of Work	As per progress report
6. Amount Payable by this Inspection	LKR 10,437,206.77
7. Note	Work progress in the report is 97.51% (Rs. 33,923,186.36) which is the progress percentage to the contract amount without contingency (10%). After this inspection on the completion of the work, defect liability period commences at the date of issuance and approval of Certificate of Completion for one year. The contractor should submit Maintenance Security to JICA for the defect liability.

It is confirmed that the work mentioned above has been completed according to contract, TOR, and other relevant documents.

28/08/2017
Inspection Staff

Mr. Fusato Tanaka
Chief Representative
JICA Sri Lanka Office

(Note)

1. Write the latest information if an amendment has been made.
2. List observation, findings from the on-site inspection, etc. in #7 if necessary.
3. In case of partial payment or other payments made before the completion of the contract, describe the type of the payment in #7 and put the payment amount approved by this inspection in #6. (If it is a one-time payment, put "N.A." in #6)
4. Attach related documents such as reports by supervisory staff/supervisor and On-site Inspection Record as needed.

CERTIFICATE OF PRACTICAL COMPLETION

Contract Name	Certificate of Completion of the Construction Work for the Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 1), Badulusirigama-Badulla, under the Technical Cooperation for Landslide Mitigation Project (TCLMP).
Consulting Agency	National Building Research Organization (NBRO).
Name & Address of the Contractor	ELS construction (Pvt) Ltd. No:62/3, Neelammahara Road, Katuwawala, Boralesgamuwa

Contract Price (excluding taxes)	Rs. 38,268,930.00
Date of Start	16/02/2016.
Date of Completion	28/07/2017.
Defects notification period	28/07/2017 – 28/07/2018 (one year).
Date of handing over	28/07/2017.

Description of completed work	**Remarks**
Horizontal Drain drilling and installation of PVC Pipe- 2655m length(51 holes up to 45m,55m & 60m length)	Satisfactory
Surface Drain Ditch TYPE A -44m length Surface Drain Ditch TYPE B -101m length Surface Drain Ditch TYPE C -69m length Surface Drain Ditch TYPE D -212m length Surface Drain Ditch TYPE E -338m length Surface Drain Ditch TYPE F -80m length Surface Drain Ditch TYPE GC -50m length	Satisfactory

Collecting pits- 11 numbers	Satisfactory
Gabion Box Dam at the toe of horizontal drain outlet- 58m3 (1m*1m*1m boxes)	Satisfactory

Defects to be rectified by the Contractor: None

Dr. Asiri Karunawardana
Director General
National Building Research Organization
(NBRO)
Democratic Socialist Republic of Sri Lanka

Mr. Fusato Tanaka
Chief Representative
Japan International Cooperation
Agency
(JICA)

Inspection Certificate

(Passed)

1. Name of Consulting Service Assignment	The Pilot Project for Landslide and Rock fall mitigation works (Lot 2) under the Technical Cooperation for Landslide Mitigation Project
2. Performance Period	02/02/2016 – 15/03/2017
3. Contract Amount	LKR 12,973,702.50 (Final confirmed price: LKR 12,889,701.36)
4. Name of Contractor	Geo Engineering Consultants (Pvt) Ltd
5. Progress of Work	As per project completion report
6. Amount Payable by this Inspection	LKR 4,027,530.36 (LKR 644,485.07 out of the amount can be paid upon the submission of maintenance security)
7. Note	After this inspection on the completion of the work, defect liability period commences at the date of issuance and approval of Certificate of Completion for one year. The contractor should submit Maintenance Security to JICA for the defect liability.

It is confirmed that the work mentioned above has been completed according to contract, TOR, and other relevant documents.

31 /03/2017
Inspection Staff
Fusato Tanaka
Mr. Fusato Tanaka
Chief Representative
JICA Sri Lanka Office

(Note)

1. Write the latest information if an amendment has been made.
2. List observation, findings from the on-site inspection, etc. in #7 if necessary.
3. In case of partial payment or other payments made before the completion of the contract, describe the type of the payment in #7 and put the payment amount approved by this inspection in #6. (If it is a one-time payment, put "N.A." in #6)
4. Attach related documents such as reports by supervisory staff/supervisor and On-site Inspection Record as needed.

CERTIFICATE OF PRACTICAL COMPLETION

Contract Name	Certificate of Completion of the Construction Work for the Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 2), Udamadura-Nuwara Eliya, under the Technical Cooperation for Landslide Mitigation Project (TCLMP).
Consulting Agency	National Building Research Organization (NBRO).
Name & Address of the Contractor	Geo Engineering Consultants (Pvt) Ltd. No: 929/18, Kahandawala Road, Thalangama North, Malabe.

Contract Price (excluding taxes)	Rs. 12,900,000.00
Date of Start	02/02/2016.
Date of Completion	15/03/2017.
Defects notification period	30/03/2017 – 30/03/2018 (one year).
Date of handing over	15/03/2017.

Description of completed work	**Remarks**
Horizontal Drain drilling and installation of PVC Pipe- 500m length(10 holes up to 50m length)	Satisfactory
Surface Drain Ditch TYPE A -134.2m length	Satisfactory
Surface Drain Ditch TYPE B -217.4m length	Satisfactory
Surface Drain Ditch TYPE C -114.1m length	Satisfactory
Water Collecting pits- 3 numbers	Satisfactory

Gabion Box Dam- 5m long ,2m high	Satisfactory
Concrete Small Dam- 1 number	Satisfactory
Gabion wall for cut slope- 5m long ,2m high	Satisfactory

Defects to be rectified by the Contractor: None

30th March 2017

Director General
National Building Research Organisation
99/1, Jawatta Road, Colombo 05.

Dr. Asiri Karunawardana	Mr. Fusato Tanaka
Director General	Chief Representative
National Building Research Organization	Japan International Cooperation
(NBRO)	Agency
Democratic Socialist Republic of Sri Lanka	(JICA)

Inspection Certificate

(Passed)

1. Name of Consulting Service Assignment	The Pilot Project for Landslide and Rock fall mitigation works (Lot 3) under the Technical Cooperation for Landslide Mitigation Project
2. Performance Period	28/01/2016 – 16/03/2017 (Work Period)
3. Contract Amount	LKR 32,168,235.00
4. Name of Contractor	Sanguine Engineering (Pvt) Ltd
5. Progress of Work	As per final completion report
6. Amount Payable by this Inspection	LKR 13,706,720.03 (LKR 1,531,343.12 out of the amount can be paid upon the submission of maintenance security)
7. Note	After this inspection on the completion of the work, defect liability period commences at the date of issuance and approval of Certificate of Completion for one year. The contractor should submit Maintenance Security to JICA for the defect liability.

It is confirmed that the work mentioned above has been completed according to contract, TOR, and other relevant documents.

31/03/2017
Inspection Staff

Mr. Fusato Tanaka
Chief Representative
JICA Sri Lanka Office

(Note)

1. Write the latest information if an amendment has been made.
2. List observation, findings from the on-site inspection, etc. in #7 if necessary.
3. In case of partial payment or other payments made before the completion of the contract, describe the type of the payment in #7 and put the payment amount approved by this inspection in #6. (If it is a one-time payment, put "N.A." in #6)
4. Attach related documents such as reports by supervisory staff/supervisor and On-site Inspection Record as needed.

CERTIFICATE OF PRACTICAL COMPLETION

Contract Name	Certificate of Completion of the Construction Work for the Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 3), Alangumale-Matale, under the Technical Cooperation for Landslide Mitigation Project (TCLMP).
Consulting Agency	National Building Research Organization (NBRO).
Name & Address of the Contractor	Sanguine Engineering (Pvt) Ltd. No: 51/25, Lumbini Mawatha, Dalugama, Kalaniya.

Contract Price (excluding taxes)	Rs. 32,168,235.00
Date of Start	18/01/2016.
Date of Completion	16/03/2017.
Defects notification period	30/03/2017 – 30/03/2018 (one year).
Date of handing over	16/03/2017.

Description of completed work	**Remarks**
Excavation for canal (ditch)- 1232.7m^3	Satisfactory
Rock excavation for structures/reshaping the slope/berms using control blasting and disposal of excess materials -464.1m^3	Satisfactory
Filling to embankment using existing soil at downside of the slope including compaction-730.8015m^3	Satisfactory
Levelling of excavated cannel and disposal of materials-90.04m^3	Satisfactory

Supplying and placing of rubble stone pitching top of the earth embankment and bottom of the cannel-676.7m^2	Satisfactory
Temporary road construction-100m	Satisfactory
Supplying, assembling and placing of PVC coated gabion wall boxes-213m^3	Satisfactory
Surface drainage work- 1 item	Satisfactory

Defects to be rectified by the Contractor: None

30th March 2017

Director General
National Building Research Organisation
99/1, Jawatta Road, Colombo 05.

Dr. Asiri Karunawardana
Director General
National Building Research Organization
(NBRO)
Democratic Socialist Republic of Sri Lanka

Mr. Fusato Tanaka
Chief Representative
Japan International Cooperation
Agency
(JICA)

Appendix 8-7

Certificate of defect liability period of the pilot sites

Defects Liability Certificate

Contract Name	Certificate of Satisfaction of the Construction Work for the Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 1), Badulusirigama-Badulla, under the Technical Cooperation for Landslide Mitigation Project (TCLMP)
Consulting Agency	National Building Research Organisation (NBRO)
Name & Address of the Contractor	ELS Construction (Pvt) Ltd. No:62/3, Neelammahara Road, Katuwawala, Boralesgamuwa

Contract Price (excluding taxes)	Rs.38,268,930.00
Date of Start	16/02/2016
Date of Completion	28/07/2017
Defects notification period	28/07/2017 – 28/07/2018(one year)
Date of handing over	28/07/2017

Description of completed work	**Remarks**
Horizontal Drain drilling and installation of PVC Pipe – 2,655m length (51 holes up to 45m, 55m and 60m length)	Satisfactory
Surface Drain Ditch Type A- 44m length	Satisfactory
Surface Drain Ditch Type B- 101m length	Satisfactory
Surface Drain Ditch Type C- 69m length	Satisfactory
Surface Drain Ditch Type D- 212m length	Satisfactory
Surface Drain Ditch Type E- 338m length	Satisfactory
Surface Drain Ditch Type F- 80m length	Satisfactory
Surface Drain Ditch Type G- 50m length	Satisfactory
Water Collecting Pits – 11 numbers	Satisfactory
Gabion Box Dam at the toe of horizontal drain outlet - 58m3 (1m*1m*1m boxes)	Satisfactory

Defects to be rectified by the Contractor: None

Dr. Asiri Karunawardana
Director General
National Building Research Organisation
(NBRO)
Democratic Socialist Republic of Sri Lanka

24-7-2018

Director General
National Building Research Organisation
No. 99/1, Jawatta Road,
Colombo 05.

Final Report

20th July, 2018

Project: The Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 1), Badulusirigama-Badulla, under the Technical Cooperation for Landslide Mitigation Project (TCLMP)

1. Outline of Defect Liability Inspection

   Site: Badulusirigama, Badulla (Lot 1)

   Date: 19th July 2018 9:30-11:30 AM

   Participants:

   Mr. Hiroki Hashimoto (JICA)
   Mr. Takayuki Nagai (JICA Long Term Expert)
   Mr. R.M.S. Bandara (NBRO HQ)
   Dr. Pathmakumara Jayasingha (NBRO HQ)
   Mr. C.M.U. Moremada (NBRO Badulla District Office)
   Ms. A.D.Harshani Jeewanthi Perera (NBRO Badulla District Office)
   Mr. R.M Palitha Madurasingha (NBRO Badulla District Office)
   Mr. Ryuichi Hara (TCLMP)
   Mr. Akira Ohkawara (TCLMP)
   Mr. Kyoichi Kawakami (TCLMP)
   Mr. Takashi Ogino (TCLMP)
   Mr. Tomoyuki Nishikawa (TCLMP)
   Ms. G. Dilupa P. De Zoysa (ELS Constructions)

2. Result of the Inspection

   1) Horizontal Drainage drilling

   There are no defects at these facilities.

   2) Surface Drainage Ditch

   There are no defects at these facilities.

   3) Other Facilities

   There are no defects at these facilities such as gabion walls, and water collecting pits.

3. Recommendations

   1) Horizontal Drainage Drillings

   When monitoring will be conducted, water flow rate should be measured at every drilling point. If the

water flow rate is fewer than before, necessary actions should be taken such as cleaning of the PVC pipes. Also if the catch pits in front of the gabion walls are filled by soils, the soils should be removed and keep the proper functions of the catch pits.

2) Surface Drainage Ditch

If the surface drainage ditches and the catch pits are blocked by soils/ rocks, the soils/ rocks should be removed. Also any damages such as cracks are found, the damages should be repaired immediately.

3) Other Facilities

If any damages are found at other facilities, the damages should be repaired. Also wild fires occurred in the site, check the damages of the facilities and equipment for monitoring such as extensometers, and the damages should be repaired immediately. It is better to continue monitoring by equipment at least three years and monitor the movement of the landslide.

4) Maintenance

Maintenance should be conducted according to the Minutes of Meeting of the JCC held on 4th October 2017 shown below.

3 Recommendations and lessons learned:

b- Proper maintenance of the Facilities after the completion of the Project

The Team pointed out the importance of the continuous monitoring and proper maintenance of the Facilities after the completion of the Project so as to secure sustainability. NBRO agreed to make monitoring with a check sheet at least two times per year after the rainy seasons (monsoons), especially after heavy rainfall and maintain the Facilities properly by themselves. NBRO also agreed that whenever necessity arises, such as any major damages occur, NBRO should inform it with its actions to be taken to JICA Sri Lanka Office.

Dr. Pathmakumara Jayasingha
NBRO LRRMD

Mr. Ryuichi Hara
TCLMP

Mr. R.M.S. Bandara
Director, NBRO LRRMD

Defect Liability Inspection at the site

Wrap up meeting after the inspection

Monitoring Sheet

Summary Sheet (Badulusirigama)

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017		

Facility	Location No	Outline of monitoring result Evidence of damage level	Damage level	Comment, countermeasure, etc.
Surface drainage ditch	1	Side part of the ditch is eroded by surface water flow.	III (b)	Already corrected. However, continuous monitoring is required.
	2	Side part of the ditch is eroded by surface water flow.	III (b)	Already corrected. However, continuous monitoring is required.
	3	The slope near the ditch is eroded by surface water flow.	III (b)	Already corrected. However, continuous monitoring is required. (This location has been move to Horizontal drilling No.1)
	4	Soils are flowing into the ditch due to the surface water flow. At the moment, the ditch is not blocked by the soils.	III (b)	At the moment, the ditch is not blocked by the soils. If soils block the ditch completely, soils should be removed. (Soils were washed away.)
	5	Small crack is appeared on the shoulder of the ditch due to the inappropriate compaction or other causes.	III (b)	The crack at the side walls and base concrete has been corrected.
	6	The ditch is blocked by a rock. At the moment, the ditch is not blocked by the soils completely.	III (b)	If soils/ rocks block the ditch completely, soils/ rocks should be removed. (Already removed)
	7	Soils are flowing into the ditch due to the surface water flow. At the moment, the ditch is not blocked by the soils.	III (b)	Already removed. However, continuous monitoring is required.
	8	Soils are flowing into the ditch due to the surface water flow. At the moment, the ditch is not blocked by the soils.	III (b)	Already removed. However, continuous monitoring is required.
	9	Soils are flowing into the ditch due to the surface water flow. At the moment, the ditch is not blocked by the soils.	III (b)	Already removed. However, continuous monitoring is required.
	10	A crack is appeared on the ditch.	III(b)	Already corrected. However, continuous monitoring is required.
	11	A crack is appeared on the ditch.	III(b)	Already corrected. However, continuous monitoring is required.
Water collecting pit	1	Water is leaked from the weep holes.	III (b)	Already corrected. However, continuous monitoring is required.
	2		IV(a)	
	3		IV(a)	
	4		IV(a)	
	5		IV(a)	
	6		IV(a)	
	7		IV(a)	
	8	Soils flow into the pit due to surface water.	III (b)	Already removed. However, continuous monitoring is required.
	9		IV(a)	
	10	Soils flow into the pit due to surface water.	III (b)	Already removed. However, continuous monitoring is required.
	11	Soils flow into the pit and almost block the pit due to surface water.	III (b)	Already removed. However, continuous monitoring is required. If possible, it is better to conduct planting.

	12	Soils flow into the pit due to surface water.	III (b)	Already removed. However, continuous monitoring is required.
Horizontal drilling	1	The slope behind the gabion wall is eroded by surface water flow.	III (b)	Already reshaped. If possible, it is better to conduct planting.
	2		IV (a)	
	3		IV (a)	
	4		III (b)	If possible, it is better to conduct planting at the slope.
	5		III (b)	If possible, it is better to conduct planting. At the slope
	6	One of drilling pipe has been broken.	III (b)	If possible, it is better to conduct planting at the slope. One PVC connecting pipe of the Point 6 was repaired.
Ground condition around ditch	1			
	2			
	3			

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Upper part of the landslide, some erosion occurs around the ditches. Also lower part of the landslide, soils flow into the ditches and water collecting pits. This time all of the defects have been corrected, however, continuous monitoring is required.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Evaluation standard for damage level of facilities

Damage level		Description
Damage Deformation /Alteration Corrosion /Blockage	A (IV)	There are no damage/ alteration/ blockage and so on (hereinafter referred to as damage) of facility itself. Or there are slight damages observed, however there are no decreases of functional status by the damage. Therefore no countermeasure is required.
	B (III)	There are some damages such as cracks or rusting observed however there are no decreases of functional status by the damage. At the moment there are no necessity for countermeasures, however continuous monitoring is required by periodic inspection in order to clarify causes of damages or to observe expansion of the cracks.
	C (I, II)	There are extremely damages of facility itself. There are obvious decreases of functional status by the damage, or stability of member and decreases of strength are concerned.

Member of monitoring

NBRO: Ms. Harshani (Badulla District Office)

TCLMP: Mr. Hara, Kawakami, Ogino

Monitoring Sheet
Surface Drainage Ditch

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: 1,2	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	(1) Scouring 2. Subsidence	1	Loc. 1,2: Already corrected	1(2) 2(1)	III (b)
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Already corrected. However, continuous monitoring is required.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface Drainage Ditch

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: 3	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil 7. Erosion	7	Already reshaped. However, continuous monitoring is required.	3	III (b)

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Already reshaped. However, continuous monitoring is required. This item has been moved to horizontal drilling Point No.1.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface Drainage Ditch

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: 4	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment		Soils have been washed away. Therefore this location should be excluded at the moment. However, continuous monitoring is required.	(4)	III (b)
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil 7. Erosion				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) At the moment, there is no problem at this location. However, in the near future, soils could be flowed into the ditch again. If soils are blocked the ditch, soils should be removed.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface Drainage Ditch

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: 5, 10, 11	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Surface drainage ditch	Damage Deformation	(1) Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding	1	Loc. 5, 11: The cracks have been corrected. However, continuous monitoring is required. Loc. 10: The crack at the side walls and the base concrete has been corrected.	4(5) 8(10) 9(11)	5,11: III (b) 10: III (b)
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The cracks of Loc. 5 and 11 have been corrected. The crack of Loc. 10 has not been corrected completely. The crack of Loc. 10 should be corrected before the end of the defect liability period.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface Drainage Ditch

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: 6, 12	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment		Loc. 6, 12 : The rocks blocked the ditch has been removed. However, continuous monitoring is required.	6(12)	III (b)
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil 7. Erosion				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The rocks have been removed. However, continuous monitoring is required.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Surface Drainage Ditch

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: 7, 8, 9	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment	3	Loc. 7, 8, 9: The soils have been removed. However, continuous monitoring is required. If soils flow into the ditches again, the soils should be removed.	5(7) 6(8) 7(9)	III (b)
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment	3	Catch pit 9, 10, 12: The soils have been removed. However, continuous monitoring is required. If soils flow into the pits again, the soils should be removed.	5(9) 6(10) 7(12)	III (b)
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil 7. Erosion				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The soils have been removed at all of the locations. However, continuous monitoring is required. If soils flow into the pits again, the soils should be removed.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Surface Drainage Ditch

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: Catch pit No.1	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment	3			
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage	8	The leakage has been corrected. However, continuous monitoring is required.	12	III(b)
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil 7. Erosion				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Weep holes has been blocked on order to prevent leakages from the weep holes.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Horizontal Drainage Drilling

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: Drilling Point 1, 4	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
PVC pipe	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Connecting pipe	Blockage	1. Blockage 2. Clogging				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Drainage pipe connecting to ditch	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Ground condition around drilling point	Damage Deformation	(1) Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil	1	The small slip has been reshaped. However, continuous monitoring is required.	3(1) 10(4)	III (b)

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The small slip has been corrected. However, continuous monitoring is required. If possible, it is better to conduct planting at the reshaped slope.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Horizontal Drainage Drilling

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: Drilling Point 2, 3, 5	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
PVC pipe	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Connecting pipe	Blockage	1. Blockage 2. Clogging				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Drainage pipe connecting to ditch	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Ground condition around drilling point	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) No problem (Almost same condition as the last monitoring) No.5: If possible, it is better to conduct planting at the slope around the gabion. (Almost same condition as the last monitoring)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Horizontal Drainage Drilling

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: Drilling Point 6	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
PVC pipe	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Connecting pipe	Blockage	1. Blockage 2. Clogging				
	Damage Deformation	1. Crack (2.) Fracture 3. Gap 4. Bending	2	Broken PVC connecting pipe of the Point 6 was repaired.	12	IV (a)
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding (3.) Sediment	3	The soils have been removed. However, continuous monitoring is required.	11	III (b)
Drainage pipe connecting to ditch	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Ground condition around drilling point	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The soils have been removed. However, continuous monitoring is required. If possible, countermeasures such as planting on the slopes should be considered. Broken PVC connecting pipe of the Point 6 was repaired.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Horizontal Drainage Drilling

Flow Rate

Date: 19 July 2018

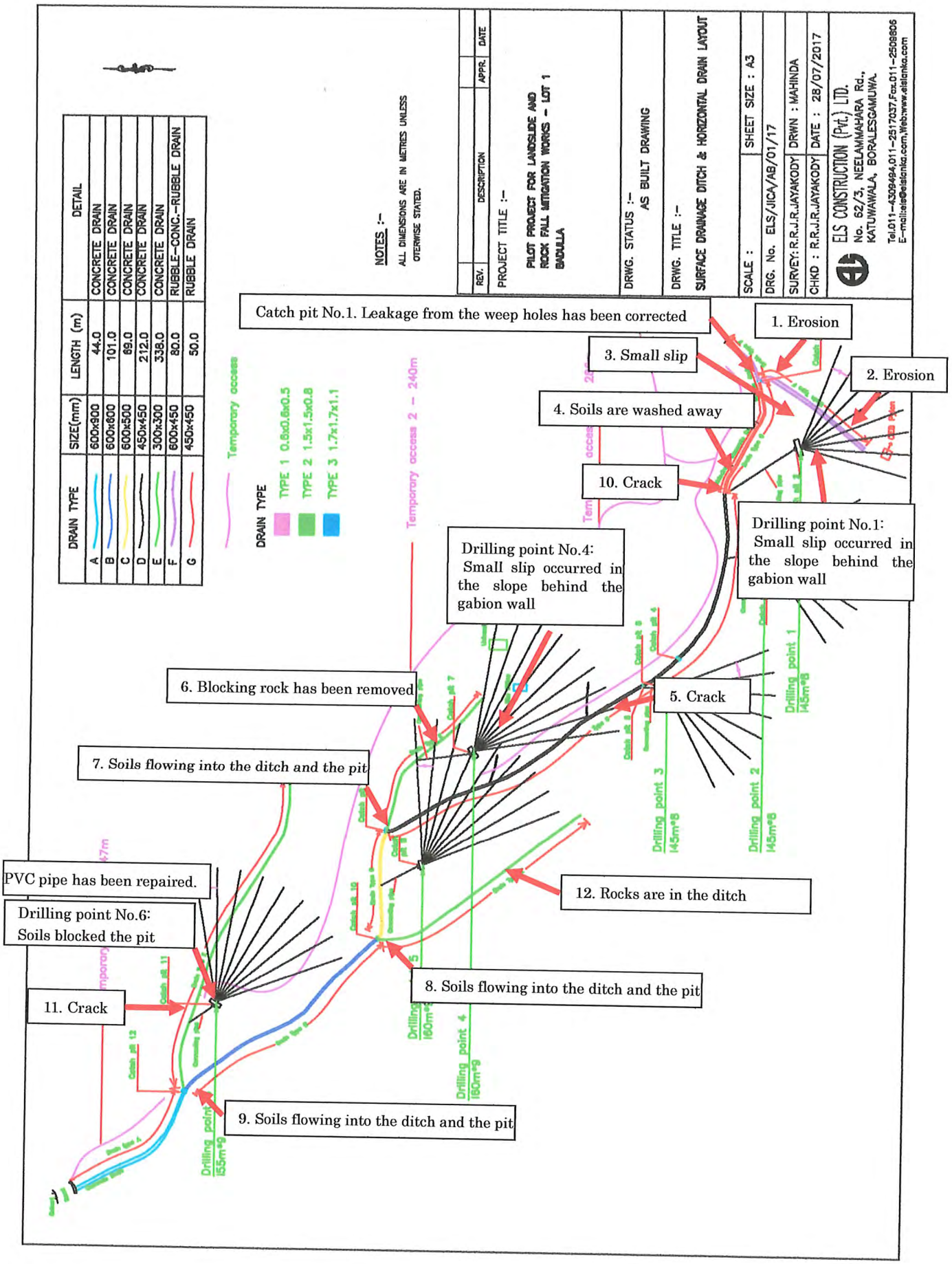
Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: Drilling Point	(shown in the map)

Point	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	Total (l/min)
1	*	*	*					*		0.65
2										0
3										0
4	*	*	*	*	*	*	*	*	*	3.91
5				*		*	*	*	*	1.29
6				*	*	*	*	*	*	2.98

Note: If it's difficult to measure flow rate one by one, measure total rate.

*: Water from the hole



DRAIN TYPE	SIZE(mm)	LENGTH (m)	DETAIL
A	600x900	44.0	CONCRETE DRAIN
B	600x600	101.0	CONCRETE DRAIN
C	600x500	69.0	CONCRETE DRAIN
D	450x450	212.0	CONCRETE DRAIN
E	300x300	338.0	CONCRETE DRAIN
F	600x450	80.0	RUBBLE-CONC.-RUBBLE DRAIN
G	450x450	50.0	RUBBLE DRAIN

Monitoring Sheet

Photo

Date: 19 July 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location:	(shown in the map)

Photo 1: Erosion has been corrected (Loc.2)

Photo 2: Erosion has been corrected (Loc.1)

Photo 3: Small slip has been reshaped (D. P. 1)

Photo 4: Cracks have been corrected (Loc.5)

Photo 5: Soils have been removed (Loc.7)

Photo 6: Rocks have been removed (Loc.12)

Monitoring Sheet

Photo

Date: 19 June 2018

Affiliation: TCLMP Name: NBRO, TCLMP

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location:	(shown in the map)

Photo 7: Soils have been removed (Loc.8)

Photo 8: Soils have been removed (Loc.9)

Photo 9: Crack has been corrected (Loc.11)

Photo 10:The small slip has been reshaped (D.P.4)

Photo 11: Soils have been removed (D.P.6)

Photo 12: PVC pipe has been repaired (D.P.6)

Defects Liability Certificate

Contract Name	Certificate of Satisfaction of the Construction Work for the Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 2), Udamadura-Nuwara Eliya, under the Technical Cooperation for Landslide Mitigation Project(TCLMP)
Consulting Agency	National Building Research Organisation (NBRO)
Name & Address of the Contractor	Geo Engineering Consultants (Pvt) Ltd. No.929/18, Kahandawala Road, Tha

Contract Price (excluding taxes)	Rs.12,978,377.5
Date of Start	02/02/2016
Date of Completion	15/03/2017
Defects notification period	30/03/2017 – 30/03/2018(one year)
Date of handing over	15/03/2017

Description of completed work	**Remarks**
Horizontal Drain drilling and installation of PVC Pipe – 500m length (10 holes up to 50m length)	Satisfactory
Surface Drain Ditch Type A-134.2m length	Satisfactory
Surface Drain Ditch Type B-2127.4m length	Satisfactory
Surface Drain Ditch Type C-114.1m length	Satisfactory
Water Collecting Pits – 3 numbers	Satisfactory
Gabion Box Dam – 5m long, 2m high	Satisfactory
Concrete Small Dam – 1 number	Satisfactory
Gabion wall for cut slope 5m long, 2m high	Satisfactory

Defects to be rectified by the Contractor: None

Dr. Asiri Karunawardana
Director General
National Building Research Organisation
(NBRO)
Democratic Socialist Republic of Sri Lanka

Director General
National Building Research Organisation
99/1, Jawatta Road, Colombo 05.

Final Report

15th March 10, 2018

Project: The Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 2), Udamadura-Nuwara Eliya, under the Technical Cooperation for Landslide Mitigation Project (TCLMP)

1. Outline of Defect Liability Inspection

   Site: Udamadura, Nuwara ELiya (Lot 2)

   Date: 8th March 2018 10:00-11:30 AM

   Participants:

   Mr. Hiroki Hashimoto (JICA)

   Mr.Takayuki Nagai (JICA Long Term Expert)

   Dr. Pathmakumara Jayasingha (NBRO HQ)

   Mr. Malaka Hettiarachchi (NBRO Nuwara Eliya District Office)

   Mr. Ryuichi Hara (TCLMP)

   Mr. Kyoichi Kawakami (TCLMP)

   Mr. Akira Sasaki (TCLMP)

   Mr. Dilum Wanigasekara (Geo Engineering)

2. Result of the Inspection

   1) Horizontal Drainage drilling

   A collapse occurred at the right side of the gabion wall on 29th January.

   The cause of the collapse was excessive precipitation therefore this collapse is not a defect by the Contractor.

   There is no defect at this facility.

   2) Surface Drainage Ditch

   A part of surface drainage ditch under the water collecting pit was not corrected properly at the time of the inspection. After the instruction by the Engineer, the Contractor has corrected the ditch properly after the inspection.

   Also there are some leakages and erosions at the ditches. However, it was very difficult to find the exact place of those phenomena in this inspection.

   3) Other Facilities

   There is no defect at these facilities such as gabion dam, concrete dam and water collecting pit.

3. Recommendations

1) Horizontal Drainage Ditch

The collapse is not a defect by the Contractor, however, countermeasures against the collapse should be conducted.

The Engineer (NBRO, TCLMP) should discuss with the Contractor and take necessary action immediately.

2) Surface Drainage Ditch

The leakages and erosions should be inspected during the dry season. Based on the inspection, necessary actions such as correction should be taken.

Farmers use water from the holes of the ditch for their paddy field. The purpose of the surface drainage ditch is to drain the surface water inside the landslide area to the outside of the landslide area. To get the water from the ditch to the farmer's paddy field through natural ditch is not good for the landslide. Therefore, the natural ditch should be covered by such as polyethylene sheets to avoid the infiltration of ground water to under the ground.

3) Other Facilities

There is no recommendation.

4) Maintenance

Maintenance should be conducted according to the Minutes of Meeting of the JCC held on 4th October 2017 shown below.

3 Recommendations and lessons learned:

b- Proper maintenance of the Facilities after the completion of the Project

The Team pointed out the importance of the continuous monitoring and proper maintenance of the Facilities after the completion of the Project so as to secure sustainability. NBRO agreed to make monitoring with a check sheet at least two times per year after the rainy seasons (monsoons), especially after heavy rainfall and maintain the Facilities properly by themselves. NBRO also agreed that whenever necessity arises, such as any major damages occur, NBRO should inform it with its actions to be taken to JICA Sri Lanka Office.

Dr. Pathmakumara Jayasingha
NBRO LRRMD

Mr. Ryuichi Hara
TCLMP

Mr. R.M.S. Bandara
Director, NBRO LRRMD

Defect Liability Inspection at the site

After the correction of the ditch near the catch pit

Monitoring Sheet

Summary Sheet（Udamadura）

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location:	(shown in the map)

Facility	Location No	Outline of monitoring result Evidence of damage level	Damage level	Comment, countermeasure, etc.
Surface drainage ditch	1	Crack is appeared on the ditch side.	III (b)	The crack has been corrected. However, at the moment continuous monitoring is necessary.
	2	Leakages are found at the base concrete.	III (b)	The leakages have been corrected. However, at the moment continuous monitoring is necessary
	3	Ditch is not constructed properly.	I,II (c)	The ditch should be constructed properly before the end of the defect liability period.
	4	Leakages are found at the base concrete.	III (b)	The leakages have been corrected. However, at the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places of leakages. Still continuous monitoring is necessary.
	5	Crack is appeared on the ditch side.	III (b)	The crack has been corrected. However, at the moment continuous monitoring is necessary.
	6	Sedimentation in the ditch.	III (b)	Sediments have been removed. However, before the rainy season, it should be monitored.
	7	The wall of the pit is eroded	III (b)	The wall of the pit has been corrected. However, at the moment continuous monitoring is necessary.
	8	Crack is appeared along the expansion joint.	III (b)	The crack has been corrected. However, at the moment continuous monitoring is necessary.
	9	Base concrete has been eroded by water flow.	III (b)	At the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places of erosion. Continuous monitoring is necessary.
	10	Leakages are found at the base concrete.	III (b)	The leakages have been corrected. However, at the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places of leakages. Still continuous monitoring is necessary.
	11	Connection part of side wall and base concrete is eroded by water.	III (b)	The erosion has been corrected. However, after the correction, the same part has been eroded again. The leakages should be corrected before the end of the defect liability period.
	12	Base concrete has been eroded by water slow.	III (b)	At the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places of erosion. Continuous monitoring is necessary.
	13	Leakages are found at the side wall of the ditch	III (b)	The leakages have been corrected. However, at the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places of leakages. Still continuous monitoring is necessary.
	14	Overflow	III(b)	The overflow has been corrected by an additional wall. However continuous monitoring is necessary.

Water collecting pit	1	Some parts are eroded and washed away. (Same as No.7 of ditch)	III (b)	The wall of the pit has been corrected. However, at the moment continuous monitoring is necessary.
Horizontal drainage drilling	1	Damaged horizontal drainage pipe by collapse.	I, II (c)	Right side of the gabion wall collapsed at the end of January, 2018. Regarding the horizontal drainage drilling, broken connection joint should be repaired. And around the collapsed slope area should be back filling and stabilized.
		Overflow from the pit during heavy rain.	III (b)	Water collecting pit is overflowing at the time of heavy rain. Continuous monitoring is necessary.
Ground condition around ditch	1			
	2			
	3			

<Comprehensive judgement>

Gave	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Most of the defect has been corrected such as cracks, leakages, etc. However, regarding the leakages, it is quite difficult to find the exact places due to the too much flow water as last month. Therefore continuous monitoring is necessary. Regarding the improper ditch, the Engineer gave an instruction to the Contractor to correct the dich properly. Around the horizontal drilling, broken connection joint by collapse has been repaired. But the collapsed slope area has not been back filling and stabilized. The collapse is not a defect by the Contractor, however countermeasures against the collapse should be conducted. The Engineer (NBRO, TCLMP) should discuss with the Contractor and take necessary action immediately. When heavy rain fall, too much ground water come from the drilling holes and the pit is overflowed. Necessary countermeasures should be conducted in the future.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Evaluation standard for damage level of facilities

Damage level		Description
Damage Deformation /Alteration Corrosion /Blockage	a (IV)	There are no damage/ alteration/ blockage and so on (hereinafter referred to as damage) of facility itself. Or there are slight damages observed, however there are no decreases of functional status by the damage. Therefore no countermeasure is required.
	b (III)	There are some damages such as cracks or rusting observed however there are no decreases of functional status by the damage. At the moment there are no necessity for countermeasures, however continuous monitoring is required by periodic inspection in order to clarify causes of damages or to observe expansion of the cracks.
	c (I, II)	There are extremely damages of facility itself. There are obvious decreases of functional status by the damage, or stability of member and decreases of strength are concerned.

Member of monitoring

NBRO: Dr. Pathmakumara Jayasingha (HQ), Mr. Malaka Hettiarachchi (Nuwara Eliya District Office)

TCLMP: Mr. Ryuichi Hara, Mr. Kyoichi Kawakami, Mr. Akira Sasaki

Monitoring Sheet

Surface Drainage Ditch

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: 1, 5, 8	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc No.)	Damage level
Surface drainage ditch	Damage Deformation	(1). Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding	1	Loc. 1, 5, 8: Cracks have been corrected.	1(1) 6(5) 10(8)	III (b)
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The cracks have been corrected. However, at the moment continuous monitoring is necessary.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface Drainage Ditch

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: 2, 4, 10, 13	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding	8	Loc. 2: Leakage has been corrected. Loc. 4, 10, 13: Leakages have been corrected. But it is quite difficult to find the exact places of leakages.	2(2) 4(10) 9(13)	III (b)
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Leakages have been corrected. However, at the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places at the almost part of the leakages. Still continuous monitoring is necessary.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface Drainage Ditch

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: 3	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding (10) Others	10	The ditch lower part of the pit has not been constructed properly. It has been corrected once, but a little gap remains at the side wall.	3(3)	I, II(c)
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The ditch has been corrected once. However the function is not satisfied original design. Therefore the ditch shall be corrected property before the end of the reliability period. .
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

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Monitoring Sheet

Surface Drainage Ditch

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: 6	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment	3	Sands and soils are washed away.		III(b)
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Sediments have been washed away. However, continuous monitoring is necessary.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface Drainage Ditch

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: 7, 9, 11, 12	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap (4.) Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding	4	No. 9, 12: Base concretes have been corrected. However, at the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places No.11: Eroded part was corrected once, same part have been eroded again.	4(9) 7(11) 8(12)	III (b)
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The ditch and pit has been corrected. But some parts of the ditch seem to be eroded by the water flow. Also the pit should be cleaned and keep its function. Continuous monitoring is necessary. At the moment, amount of flowing water is too much. Therefore, it is quite difficult to find the exact places of eroded part.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet
Surface Drainage Ditch

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: 14	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc No.)	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment	1	Additional side wall has been constructed for the overflowing.	11(14)	III (b)
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) The overflow has been corrected by an additional wall. However continuous monitoring is necessary.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Horizontal Drainage Drilling

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: Drilling Point	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc No.)	Damage level
PVC pipe	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Connecting pipe	Blockage	1. Blockage 2. Clogging				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	(1). Overflow 2. Ponding 3. Sediment	1	When a heavy rain falls, the pit is over flowed.		III (b)
Drainage pipe connecting to ditch	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Ground condition around drilling point	Damage Deformation	1. Scouring (2). Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil	2	Right side of the gabion wall collapsed at the end of January. Broken drainage pipe No. 10 has been repaired.	12	I, II (c)

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Regarding the horizontal drainage drilling, broken connection joint has been repaired. And around the collapsed slope area should be back filling and stabilized. The pit is overflowed by heavy rain. In the future, countermeasure works should be necessary.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Horizontal Drainage Drilling

Flow Rate

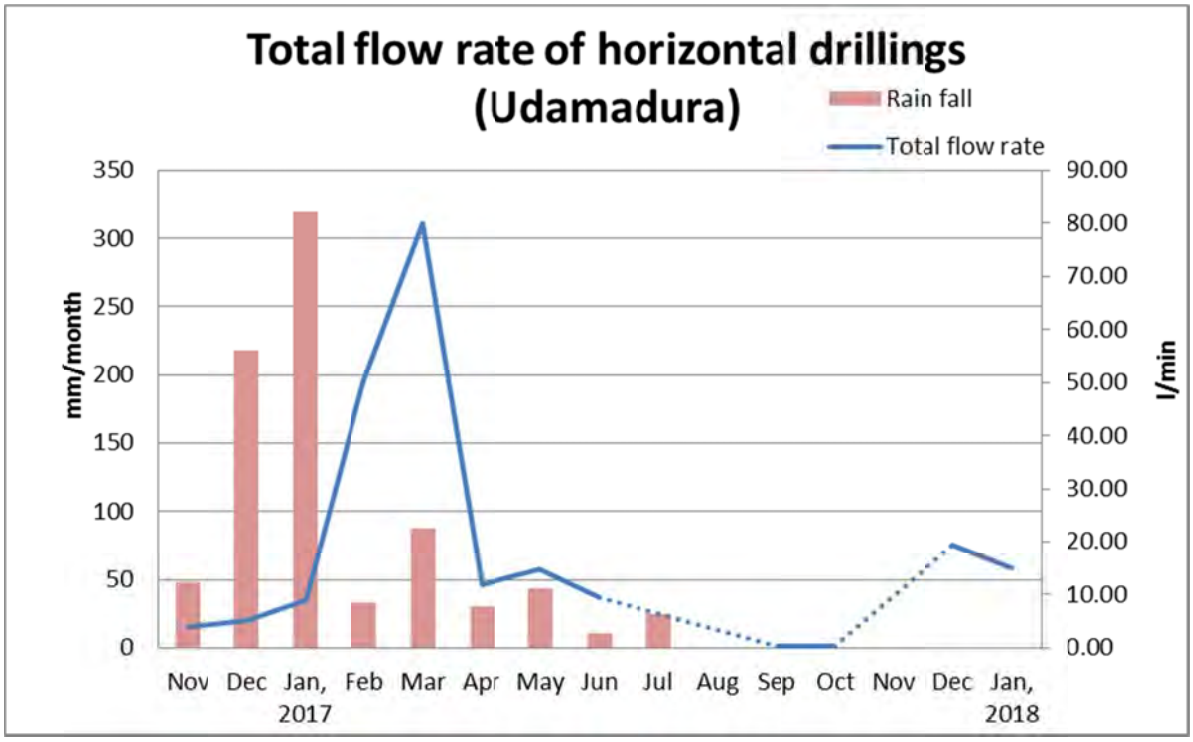
Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: Drilling Point	(shown in the map)

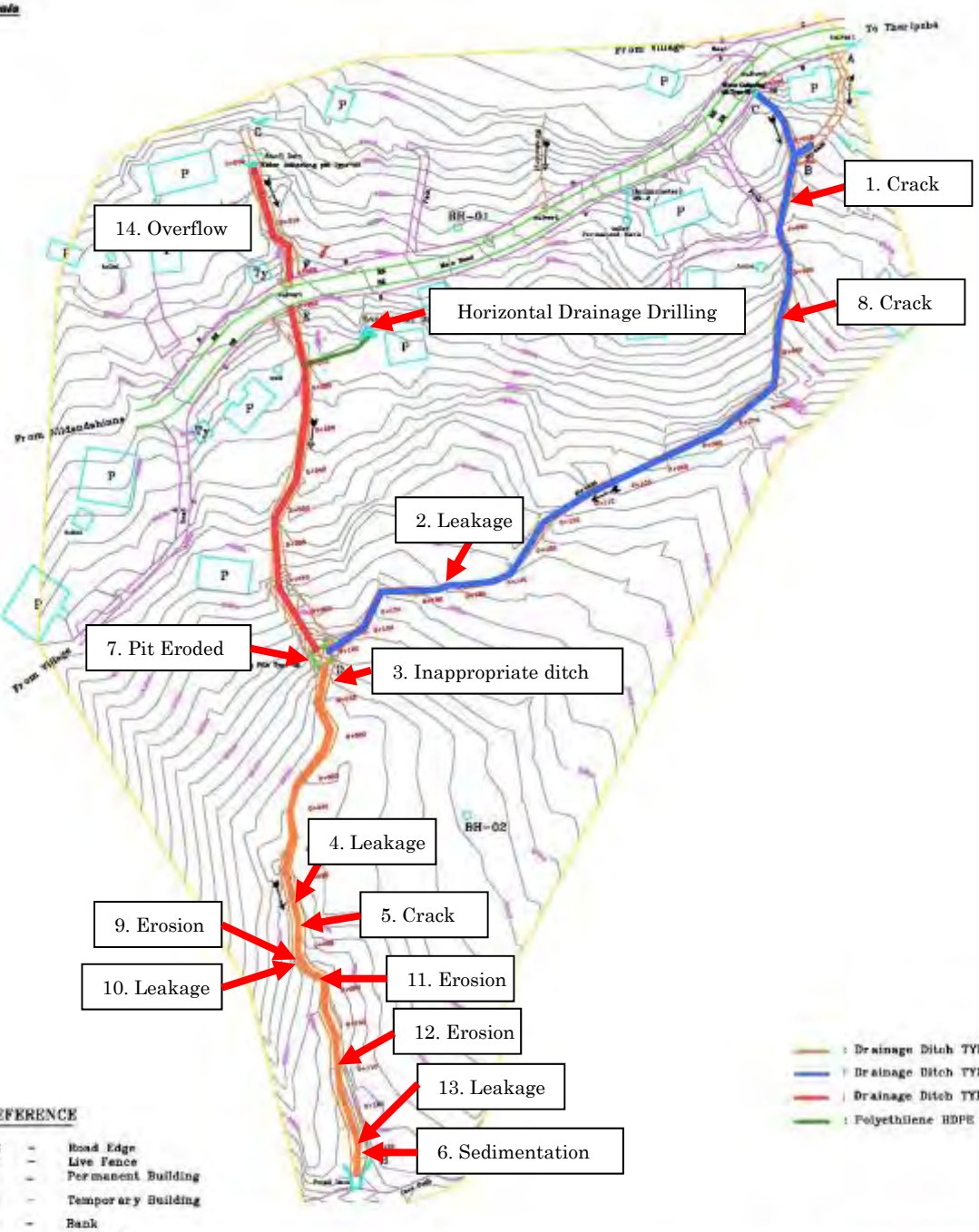
Drilling No.	1	2	3	4	5	6	7	8	9	10	Total
Flow Rate	-	-	-	-	-	-	-	-	-	-	-

Note: If it's difficult to measure flow rate one by one, measure total rate.



THE PILOT PROJECT FOR LANDSLIDE AND ROCK FALL MITIGATION WORKS
UDAMADURA, NUWARAELIYA
Finalized Survey Plan of the Area

G.K.K.Thilakaratri
Licensed Surveyor & Leveller,
No. 172/1
Bandarawatta
Handawala



Employer : Japan International Cooperation Agency Engineer : National Building Research Organization	Contractor : Geo Engineering Consultants Pvt Ltd	Surveyed on _____ Certified By:

Monitoring Sheet

Photo

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location:	(shown in the map)

	
Photo 1: Crack on the ditch has been corrected. (Loc. 1)	Photo 2: Leakages have been repaired.(Loc. 2)
	
Photo 3: The ditch lower part of the pit has not been constructed properly. After the inspection, it has been corrected.(Loc. 3)	Photo 4: Leakages have been repaired.(Loc. 10)
	
Photo 5: Crack on the ditch has been corrected. (Loc. 9)	Photo 6: Crack has been corrected. (Loc. 5)

Monitoring Sheet

Photo

Date: 8 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location:	(shown in the map)

Photo 7: Erosion at the connecting point of base concrete and side wall. Repaired once, but eroded (Loc. 11)

Photo 8: Eroded part was repaired once, but it is very difficult to find the exact place of erosion. (Loc. 12)

Photo 9: Leakage has been repaired.(Loc. 13)

Photo 10: Crack along the expansion joint has been corrected.(Loc. 8)

Photo 11: Additional wall for the overflowing has been constructed. (Loc. 14)

Photo 12: Collapse at the right side of gabion wall. (Horizontal drainage drilling No.10 was repaired)

Defects Liability Certificate

Contract Name	Certificate of Satisfaction of the Construction Work for the Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 3), Alagumale - Matale, under the Technical Cooperation for Landslide Mitigation Project(TCLMP)
Consulting Agency	National Building Research Organisation (NBRO)
Name & Address of the Contractor	Sanguine Engineering (Pvt) Ltd. No: 51/25, Lumbini Mawatha, Dalugama, Kalaniya

Contract Price (excluding taxes)	Rs.32,168,235.00
Date of Start	18/01/2016
Date of Completion	16/03/2017
Defects notification period	30/03/2017 – 30/03/2018(one year)
Date of handing over	16/03/2017

Description of completed work	**Remarks**
Excavation for canal (ditch) – 1232.7m3	Satisfactory
Rock excavation for structures/ reshaping the slope/ berms using control blasting and disposal of excess materials – 464.1m3	Satisfactory
Filling to embankment using exsiting soil at downside of the slope including compaction – 730.8015m3	Satisfactory
Levelling of excavated cannel and disposal of – 90.04mSupplying and placing of rubble stone pitching top of the earth embankment and bottom of the canal 67.67m2	Satisfactory
Temporary road construction – 100m	Satisfactory
Supplying assembling and placing of PVC, coated gabion wall boxes – 213m3	Satisfactory
Surface drainage work – 1 item	Satisfactory

Defects to be rectified by the Contractor: None

Dr. Asiri Karunawardana
Director General
National Building Research Organisation
(NBRO)
Democratic Socialist Republic of Sri Lanka

Director General
National Building Research Organisation
Jawatta Road, Colombo 05

Final Report

15th March 10, 2018

Project: The Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 3), Alagumale - Matale, under the Technical Cooperation for Landslide Mitigation Project (TCLMP)

1. Outline of Defect Liability Inspection

   Site: Alagumale, Matale (Lot 3)

   Date: 7th March 2018 14:00-15:00 PM

   Participants:

   Mr. Hiroki Hashimoto (JICA)
   Mr.Takayuki Nagai (JICA Long Term Expert)
   Dr. Pathmakumara Jayasingha (NBRO HQ)
   Ms. Bimali Amunugama (NBRO Matale District Office)
   Ms. Ayomi Wimalsinghe (NBRO Matale District Office)
   Mr. Ryuichi Hara (TCLMP)
   Mr. Kyoichi Kawakami (TCLMP)
   Mr. Akira Sasaki (TCLMP)
   Mr. Ashoka Weerasinghe (Sanguine Engineering)

2. Result of the Inspection

   1) Dyke (Ditch and Embankment with Gabion)

   There is no defect at this facility.

   2) Surface Drainage Ditch

   Some parts have been eroded, however these are not so big problems. Therefore there is no defect at this facility.

   3) Other Facilities

   Some cracks and erosions have been appeared on the embankment. However, this facility is not included in the contract between JICA and the Contractor. Therefore there is no defect at this facility.

3. Recommendations

   1) Dyke (Ditch and Embankment with Gabion)

   At the moment there is no problem. However, in the future, soils could be flowed in to the ditch from the upper slope of the ditch and fill the ditch. Or some rocks could be fallen from the upper slope to the ditch. The function of the ditch is quite important as the rock fall countermeasure. Therefore, these soils and

rocks should be removed immediately. If these phenomena occur, necessary actions should be taken.

2) Surface Drainage Ditch

If ditch is eroded, necessary actions should be taken such as repairing work.

3) Other Facilities

If the cracks and erosions are expanded, necessary actions should be taken such as removal of the embankment.

4) Maintenance

Maintenance should be conducted according to the Minutes of Meeting of the JCC held on 4th October 2017 shown below.

3 Recommendations and lessons learned:

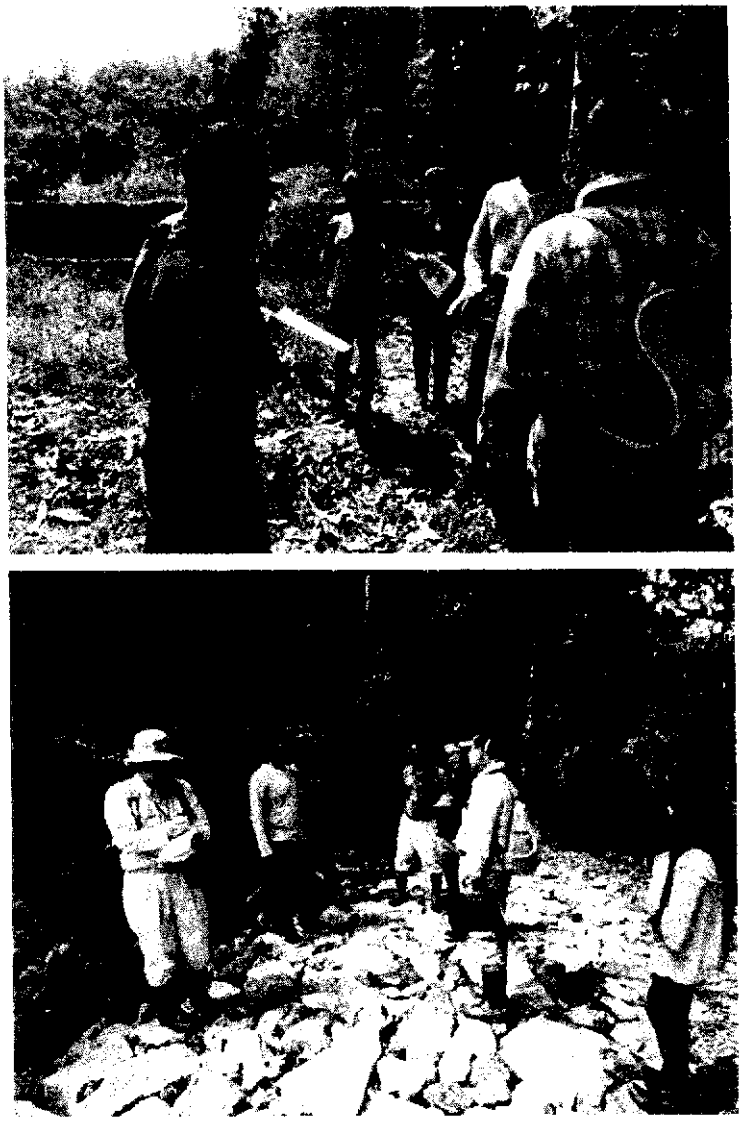
b- Proper maintenance of the Facilities after the completion of the Project

The Team pointed out the importance of the continuous monitoring and proper maintenance of the Facilities after the completion of the Project so as to secure sustainability. NBRO agreed to make monitoring with a check sheet at least two times per year after the rainy seasons (monsoons), especially after heavy rainfall and maintain the Facilities properly by themselves. NBRO also agreed that whenever necessity arises, such as any major damages occur, NBRO should inform it with its actions to be taken to JICA Sri Lanka Office.

Dr. Pathmakumara Jayasingha
NBRO LRRMD

Mr. Ryuichi Hara
TCLMP

Mr. R.M.S. Bandara
Director, NBRO LRRMD



Defect Liability Inspection at the site

Monitoring Sheet

Summary Sheet（Alagumale）

Date: 7 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location:	(shown in the map)

Facility	Location No	Outline of monitoring result Evidence of damage level	Damage level	Comment, countermeasure, etc.
Gabion wall	1			
	2			
	3			
	4			
Earth dyke	1			
	2			
	3			
Catch pocket	1			
	2			
	3			
Surface drainage ditch	1(Loc.3)	Water way of the cascade drainage ditch is eroded and some rocks are moved.	III (b)	Continuous monitoring is necessary. If the erosion is expanded, countermeasure is required. (Almost same condition as the last monitoring)
	2			
	3			
Ground condition around dyke	1(Loc.1)	Small crack is appeared on the shoulder of the embankment.	III (b)	The cracks of drying shrinkage have been disappeared. However, other small cracks have been appeared. If cracks appear at the shoulder of the embankment, continuous monitoring is necessary.
	2(Loc.2)	The shoulder of the embankment is eroded by surface water flow.	III (b)	Continuous monitoring is necessary. If the erosion is expanded, countermeasure is required.
	3(Loc.4)	Piping holes have been appeared on the embankment.	III (b)	Piping holes by erosion have been appeared. If the piping holes are expanded, countermeasure may be required.

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) At the moment there is no problem. There is no defect at the site. However continuous monitoring is necessary. If the cracks and eroded part is expanded, countermeasure is required.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Evaluation standard for damage level of facilities

Damage level		Description
Damage Deformation /Alteration Corrosion /Blockage	a (IV)	There are no damage/ alteration/ blockage and so on (hereinafter referred to as damage) of facility itself. Or there are slight damages observed, however there are no decreases of functional status by the damage. Therefore no countermeasure is required.
	b (III)	There are some damages such as cracks or rusting observed however there are no decreases of functional status by the damage. At the moment there are no necessity for countermeasures, however continuous monitoring is required by periodic inspection in order to clarify causes of damages or to observe expansion of the cracks.
	c (I, II)	There are extremely damages of facility itself. There are obvious decreases of functional status by the damage, or stability of member and decreases of strength are concerned.

Member of monitoring

NBRO: Dr. Pathmakumara Jayasingha (HQ), Ms. Ayomi Wimalsinghe, Ms. Bimali Amunugama (Matale District Office)

TCLMP: Mr. Ryuichi Hara, Mr. Kyoichi Kawakami, Mr. Akira Sasaki

Monitoring Sheet

Ground condition around dyke

Date: 7 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location: 1	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Earth dyke	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring 8. Erosion of surface 9. Removal of pitch stone				
Catch pocket	Blockage	1. Blockage by rock fall 2. Blockage by sediment				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Jutting 5. Souring 6. Erosion				
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8.Scouring 9. Erosion 10. Removal of pitch stone				
	Blockage	1. Blockage by Rock fall 2. Blockage by Sediment				
Ground condition around dyke	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil	3	The cracks of drying shrinkage have been disappeared. However, other small cracks have been appeared. If cracks appear at the shoulder of the embankment, continuous monitoring is necessary.	1 (1)	III (b)

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) At the moment there is no problem. Small cracks have been appeared. It is better to monitor the cracks at the shoulder of the embankment.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Ground condition around dyke

Date: 7 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location: 2, 4	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Earth dyke	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring 8. Erosion of surface 9. Removal of pitch stone				
Catch pocket	Blockage	1. Blockage by rock fall 2. Blockage by sediment				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Jutting 5. Souring 6. Erosion				
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8.Scouring 9. Erosion 10. Removal of pitch stone				
	Blockage	1. Blockage by Rock fall 2. Blockage by Sediment				
Ground condition around dyke	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil	1	Loc.2: The shoulder of the embankment is eroded. Loc.4: Piping holes by erosion on the embankment have been appeared.	2(2) 4(4)	III (b)

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) At the moment there is no problem. However continuous monitoring is necessary. If the erosion and the piping holes are expanded, countermeasure is required.
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Monitoring Sheet

Surface drainage ditch

Date: 7 March 2018

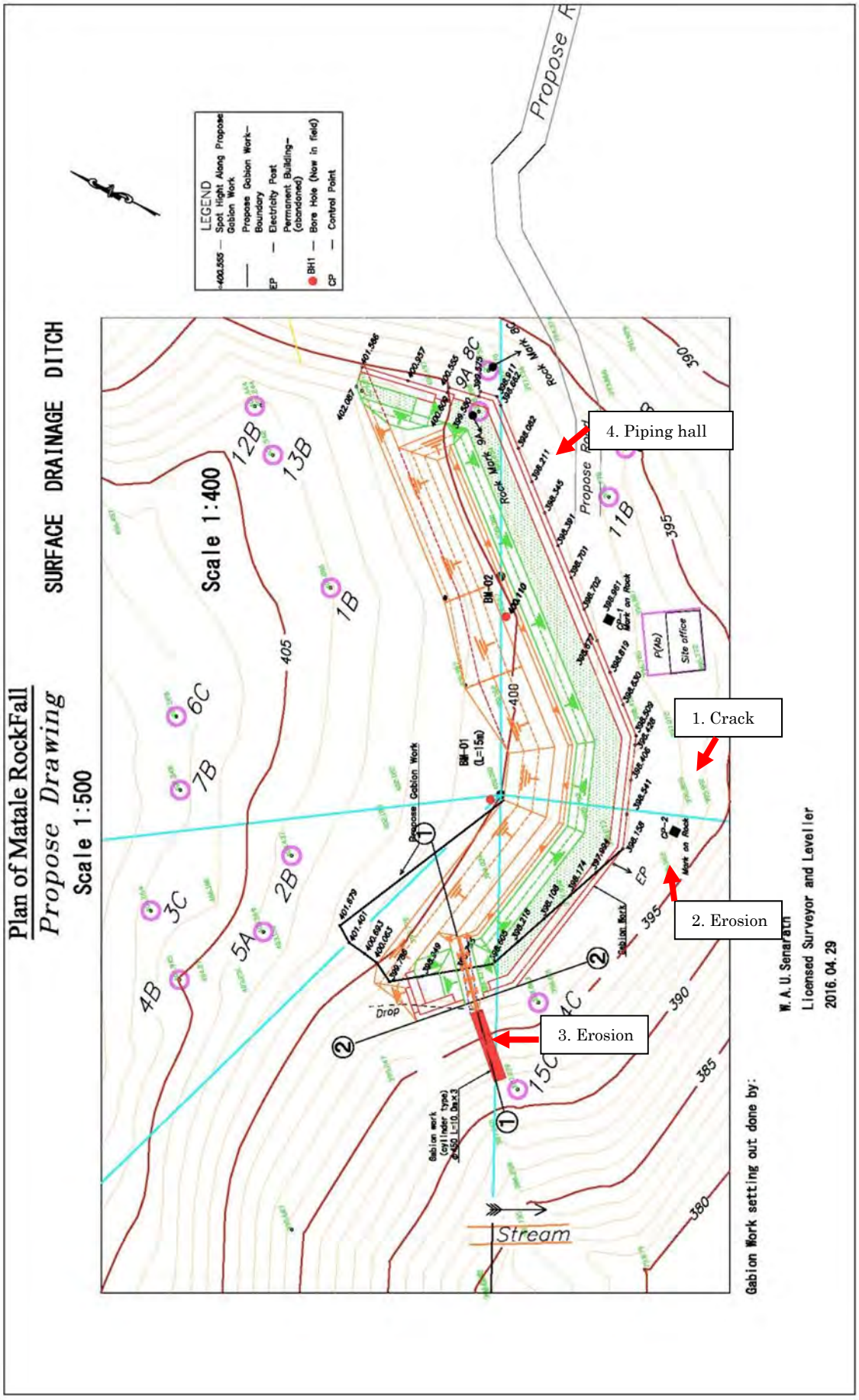
Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location: 3	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No. (Loc.No.)	Damage level
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Earth dyke	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring 8. Erosion of surface 9. Removal of pitch stone				
Catch pocket	Blockage	1. Blockage by rock fall 2. Blockage by sediment				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Jutting 5. Souring 6. Erosion				
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8.Scouring 9. Erosion 10. Removal of pitch stone	9	Water way of the cascade ditch is eroded, and some rocks are moved. (Almost same condition as the last monitoring)	3 (3)	III (b)
	Blockage	1. Blockage by Rock fall 2. Blockage by Sediment				
Ground condition around dyke	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.) Continuous monitoring is necessary. (Almost same condition as the last monitoring)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		


Plan of Matale RockFall
Propose Drawing
SURFACE DRAINAGE DITCH
Scale 1:500
Scale 1:400
LEGEND
Spot Hight Along Propose Gabion Work
Propose Gabion Work--Boundary
Electricity Post
Permanent Building--(abandoned)
Bore Hole (Now in field)
Control Point
Propose Road
Rock Work
Propose Gabion Work
Site office
Stream
Drop
Gabion work (cylinder type) Φ=450 L=10 Qty=3
4. Piping hall
1. Crack
2. Erosion
3. Erosion
W. A. U. Senaratn
Licensed Surveyor and Leveller
2016. 04. 29
Gabion Work setting out done by:

Monitoring Sheet

Photo

Date: 7 March 2018

Affiliation: NBRO Name: NBRO, TCLMP

Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location:	(shown in the map)

	
Photo 1: Cracks at the shoulder of the embankment	Photo 2: Erosion at the shoulder of the embankment
	
Photo 3: Erosion on the waterway of cascade ditch	Photo 4: Piping hole by erosion on the embankment
	
Photo 5: Actual condition of the earth dyke	Photo 6:

Appendix 8-8

Letter of handing over of the pilot sites

Letter of Handing Over.

Under the pilot project for landslide and rock fall mitigation work (Lot 1) of The Technical Cooperation For Landslide Mitigation (TCLMP) Project funded by the Japan International Cooperation Agency (JICA), Badulusirigama Rock falling Site at University of Uwa Wellassa, Badulla of Badulusirigama Grama Niladhari Division in Badulla Divisional Secretariat Division has been successfully mitigated by the contractor; ELS constructions (Pvt) Ltd, No: 62/3, Neelammahara Road, Katuwawala, Boralesgamuwa under supervision of National Building Research Organisation (NBRO) in July, 2017.

Under this mitigation project, 2655 m long horizontal drainage drilling and 894 m long surface drainage ditches, as the mitigation measure was constructed. The mitigation project of which the cost is Rs. 38,268,930.00 (without taxes) was started 16th February, 2016 and completed in 28th July, 2017. One year defect liability period was over on 28th July, 2018. Continuous monitoring is proposed and a guideline is annexed.

After successful completion of the mitigation work, we, NBRO, hereby declare the handing over the project site to the Vice Chancellor, University of Uwa Wellassa , Badulla.

Handing over by,

Dr (Eng) Asiri Karunawardana
Director General
National Building Research Organization

Date : 08.08.2018

Taking over by,

Dr. Jayantha Lal Rathnasekara,
Vice Chancellor,
University of Uwa Wellassa,
Badulla.

Date : 08.08.2018

Recommendations

8th August, 2018

Project: The Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 1), Badulusirigama-Badulla, under the Technical Cooperation for Landslide Mitigation Project (TCLMP)

1. Horizontal Drainage Drillings

When monitoring will be conducted, water flow rate should be measured at every drilling point. If the water flow rate is decreasing, necessary actions should be taken such as cleaning of the PVC pipes.

Also if the catch pits in front of the gabion walls are filled with soils/ other materials, the soils should be removed to secure the proper functions of the catch pits.

Especially, at the slopes behind or around the gabion walls, erosions or small slips might be occurred. It should be carefully monitored after any heavy rainfall.

2. Surface Drainage Ditch

If the surface drainage ditches and the catch pits are blocked by soils/ rocks, the soils/ rocks should be removed. If any damages such as cracks are found, the damages should be repaired immediately.

3. Other Facilities

If any damages are found at other facilities, the damages should be repaired. If wild fires occurred in the site, check the damages of the facilities and equipment for monitoring such as extensometers, and the conditions should be informed to NBRO Badulla District Office immediately.

The landslide area will be covered by forests and/or bushes in future. For the proper maintenance, at least 3m buffer area from each facility should be weeded and cleanly preserved.

4. Maintenance

Maintenance and monitoring should be conducted at least two times per year after the rainy seasons (monsoons), especially after heavy rainfall and maintain the facilities properly by Uva Wellasa University with paying attention to above recommendations. If damages are found on the facilities including monitoring equipment, the University should inform NBRO Badulla District Office immediately and take necessary actions.

Dr. Pathmakumara Jayasingha
NBRO LRRMD

Mr. Ryuichi Hara
TCLMP

Mr. R.M.S. Bandara
Director, NBRO LRRMD

Letter of Handing Over
of mitigated Alangumale rock fall site in Harasgama in Matale district

Under the **Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 3)** of the **Technical Cooperation for Landslide Mitigation Project** (**TCLMP**) funded by the Japan International Cooperation Agency (JICA), **Alangumale Rock Fall Site** at the Alangumale Village of Harasgama Grama Niladhari Division in Matale Divisional Secretariat Division was successfully mitigated under the supervision of National Building Research Organisation (NBRO).

In order to minimize the risk faced by the community this mitigation project was initiated by NBRO and 103 m long earth and rock embankment was constructed as the main mitigation measure. The project was started on 18th January 2016 and completed on 16th March 2017 at a project cost of Rs. 32.2 Mn. (without taxes). The project contractor was Sanguine Engineering (Pvt) Ltd, No: 51/25, Lumbini Mawatha, Dalugama, Kelaniya. The one-year defect liability period was over by 29th March 2018.

After successful completion of the mitigation work, National Building Research Organisation intends handing over of the project site to the custody of Matale Divisional Secretariat. Maintenance Guideline of the project site is attached herewith as Annexure I.

We, the undersigned hereby declare that, the National Building Research Organisation, handed over after successful mitigation works the said Alangumale project site to the Divisional Secretary of Matale Divisional Secretariat, and that, the Divisional Secretary of Matale Divisional Secretariat, accepted the possession of said project site on 16th July 2018, by placing our signatures and seals of respective institutions on 16th July 2018 in Colombo.

Dr. (Eng.) Asiri Karunawardana
Director General
National Building Research Organisation

Director General
National Building Research Organisation
No. 99/1, Jawatta Road,
Colombo 05.

Mrs. K. P. K. L. P. Maduwanthi
Divisional Secretary
Divisional Secretariat of Matale

Recommendations

16th July , 2018

Project: The Pilot Project for Landslide and Rock Fall Mitigation Work (Lot 3), Alagumale - Matale, under the Technical Cooperation for Landslide Mitigation Project (TCLMP)

1) Dyke (Ditch and Embankment with Gabion)

At the moment there is no problem. However, in the future, soils could be flowed in to the ditch from the upper slope of the ditch and fill the ditch. Or some rocks could be fallen from the upper slope to the ditch.

The function of the ditch is quite important as the rock fall countermeasure. Therefore, these soils and rocks should be removed immediately. If these phenomena occur, necessary actions such as information to NBRO District Office, removal of soils and rocks should be taken by the Divisional Secretariat of Matale.

2) Surface Drainage Ditch

If ditch is eroded, necessary actions should be taken such as repairing work.

3) Other Facilities

If the cracks and erosions are expanded, necessary actions should be taken such as removal of the embankment.

4) Maintenance

Maintenance and monitoring should be conducted at least two times per year after the rainy seasons (monsoons), especially after heavy rainfall and maintain the Facilities properly by the Divisional Secretariat of Matale.

Dr. Pathmakumara Jayasingha
NBRO LRRMD

Mr. Ryuichi Hara
TCLMP

Mr. R.M.S. Bandara
Director. NBRO LRRMD

Appendix 8-9

Manual for design and supervision of countermeasure works

Sri Lanka
National Building Research Organization (NBRO)

The Democratic Socialist Republic of Sri Lanka

Technical Cooperation for Landslide Mitigation Project (TCLMP)

Manual for Design and Supervision of Countermeasure Works against Landslide (Sediment Disaster)

September, 2018

Japan International Cooperation Agency (JICA)

Earth System Science Co., Ltd.

Nippon Koei Co., Ltd.

Sri Lanka
National Building Research Organization (NBRO)

Manual for Design and Supervision of Countermeasure Works against Landslide (Sediment Disaster)

Table of Contents

Sri Lanka
National Building Research Organization (NBRO)

Appendix

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Abbreviations

DiMCEP	Disaster Management Capacity Enhancement Project Adaptable to Climate Change
DM	Disaster Management
DMC	Disaster Management Centre
DEM	Digital Elevation Model
DOM	Department of Meteorology
EWS	Early Warning System
GN	Grama Niladhari
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
LA	Local Authority
LDPP	Landslide Disaster Prevention Project
LRRMD	Landslide Research and Risk Management Division
MDM	Ministry of Disaster Management
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MOU	Memorandum of Understanding
NBRO	National Building Research Organization
NCDM	National Council for Disaster Management
NDMCC	National Disaster Management Coordination Committee
NDMP	National Disaster Management Plan
NDRSC	National Disaster Relief Service Centre
NGOs	Non-Governmental Organizations
RDA	Road Development Authority
SLRCS	Sri Lanka Red Cross Society
SOP	Standard Operation Procedure
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
WB	World Bank

CHAPTER 1 INTRODUCTION

1. General

1.1. Purpose of this manual

This manual aims to disseminate knowledge and lessons learnt mainly from pilot projects of the Technical Cooperation for Landslide Mitigation Project (TCLMP) to staffs of the National Building Research Organisation (NBRO) and relevant organizations. Therefore the manual does not include investigations and surveys, these contents are already explained in other existing manuals such as a manual prepared by the Disaster Management Capacity Enhancement Project (DiMCEP). The manual provides mainly design and supervision consideration for ordinary countermeasures against landslides/ sediment disasters in Sri Lanka. The manual would not be part of existing manuals introducing Japanese techniques, the manual is based on the knowledge and lessons learnt from actual pilot projects implemented by the JICA TCLMP as mentioned above. Therefore the manual aims to be more practical and to be utilized in ordinary/ daily works in Sri Lanka.

1.2. Scope of the manual

As described above, the manual is based on the experiences of the pilot projects. There were three (3) Lots in the projects. Lot 1 at Badulusirigama in Badulla and Lot 2 at Badurusirigama in Nuwara Eliya were for landslides and Lot 3 at Alagumale in Matale was for rock fall. In Lot 1 and 2, surface drainage ditches and horizontal drainage drillings were constructed. In Lot 3, an earth dyke by an embankment and a pocket by excavation were constructed.

Chapter 2 introduces general information regarding countermeasures against landslides/ sediment disasters. Chapter 3 discusses design considerations learnt from the experiences of the pilot projects. Chapter 4 provides supervision consideration learnt from the experiences of the pilot projects. Chapter 5 provides monitoring for the condition of the facilities after the completion of the construction works.

Therefore the main scope of the manual is design and supervision considerations of the above countermeasures. The manual is applicable to ordinary countermeasures for landslides and rock falls in Sri Lanka.

CHAPTER 2 TYPE OF COUNTERMEASURES

1. General

Most of the landslides/ sediment disasters prone areas in Sri Lanka are distributed in hilly and mountainous terrain with steep slopes and highly weathered and fractured rocks. Landslides/ sediment disasters, therefore, frequently affect major road networks, buildings and agricultural lands, etc.

The plan of countermeasures against landslides (sediment disasters) shall be formulated with objectives of preventing or mitigating disasters due to landslide (sediment disasters).

2. Basic concept

Adequate countermeasures against landslide (sediment disasters) should be based on a better understanding of characteristics of the type of landslides/ sediment disasters. In undertaking planning to mitigate landslide (sediment disasters), extreme care should be paid to the following points.

1) Field investigations should start with a comprehensive evaluation of general conditions (topography, geology, vegetation, etc.). Investigators should not be unduly absorbed in details from the beginning, because initial impressions of such details may often mislead them from understanding the true condition of the site. An aerial survey with aerial photos or Unmanned Aerial Vehicle (UAV: drone) should be conducted before site reconnaissance in order to study the actual condition of disaster sites. Or at least disaster sites should be observed from opposite side of the slope of disaster sites in order to know the overall/ comprehensive condition of disaster sites instead of the aerial survey.
2) Large-scale fills or slope cutting in landslide-prone areas sometimes cause unforeseen disasters. Even construction of an access road or temporary cutting of the area for horizontal drainage drilling or other similar activities for cutting and filling cause unexpected landslide disasters. Especially extreme care should be paid in active or potential landslide areas. These cuttings and fillings should be checked and approved by the Engineer or the Employer before commencement of construction. These cutting or filling works including temporary works should be discussed in a Construction Plan prepared by the Contractors, if necessary.
3) Water is an essential factor in controlling slope stability. Drainage is the most important factor for the stability of both natural and artificial slopes. Treatment of surface water, spring water and drainage of groundwater to achieve the largest possible drawdown of its level are important methods for stabilizing slopes. Therefore essential understanding for surface drainage ditches and horizontal drainage drillings are quite important to design and supervise these countermeasures.

4) Management/ maintenance of countermeasure facilities shall be one of the most important factors to keep the function of countermeasures and find malfunction. Periodical site inspection along the facilities is a highly important activity. Site inspection sheets (monitoring sheets) should be the most important records/ histories to manage and maintain the facilities and for future design and supervision of countermeasures.
5) Safety management is recently one of the most important management activities during construction. Design and supervision of countermeasures should be conducted with extreme care for safety management and a Safety Management Plan should be submitted by the Contractors before commencement of construction and approved by the Engineer and the Employer.

3. Criteria for Selection of Countermeasures

Countermeasures for landslides/ sediment disasters are classified into several groups, in consideration of size, purpose, application, and design method, and the classifications are given in Table 2.1. Classification of the type of landslides/ sediment disasters should be the most important factors in order to conduct adequate design against landslide (sediment disasters) because the type of countermeasure should be different according to the type of landslides/ sediment disasters. A suitable combination of these methods should be implemented after consideration of the mechanism and dimension of landslide/ sediment disasters, the importance of the objects to be protected, and cost-effectiveness. Generally, countermeasures involve some or all of the following objectives:

1) Mitigating erosion and weathering of the slope surface by the use of vegetation, shotcrete and surface drainage;
2) Reducing pore-water pressures in the slope by surface and subsurface drainage;
3) Reducing shear (or destabilising) force by removing the unstable materials from the upper part of the unstable slope;
4) Increasing shear strength (or stabilising force) by adding weight to the toe of an unstable slope or by increasing shear strength along the slip surface;
5) Supporting the unstable area of the lope by the construction of retaining walls and similar structures;
6) Reducing or mitigating the damages from landslide (sediment disasters) by catch works, etc.;
7) Avoiding the unstable area by relocating a route/ building etc. or by the construction of a bridge or similar structures.

Table 2.1 gives the classification and their applicability of countermeasures for mitigating landslides/ sediment disasters.

Sri Lanka
National Building Research Organization (NBRO)

Table 2.1 Applicability of Countermeasures against Landslide (sediment disasters)

Classification		Type of works	Type of Sediment Disasters			
			LS	SF	RF	DF
1. EARTHWORK	Earthwork	**Removal**	○	○	○	×
		Rock Cutting	○	○	○	×
		Rock Pre-Splitting	△	○	○	×
		Soil Cutting	○	○	○	×
		Filling	○	○	○	×
2. VEGETATION	Vegetation	Re-Vegetation	○	○	○	○
		Hydro seeding	○	○	○	△
3. WATER DRAINAGE	Surface Drainage	**Drainage Ditch**	○	○	△	×
		Culvert	○	○	×	×
	Subsurface Drainage	**Horizontal Drainage Drilling**	○	○	○	×
		Drainage Well	○	×	×	×
		Drainage Tunnel	○	×	×	×
4. SLOPE WORK	Shotcrete Work	Shotcrete (mortar)	×	○	○	×
		Shotcrete (concrete)	×	○	○	×
	Crib Work	Crib work (Precast)	△	△	○	×
	Pitching	Stone Pitching	×	○	△	×
5. ANCHORING	Anchoring	Soil Nail	△	○	○	×
		Ground Anchor	○	○	○	×
6. WALL AND RESISTING STRUCTURES	Retaining Wall	Stone Pitching Wall	○	○	△	×
		Concrete Block Wall	○	○	△	×
		Supported Wall	△	○	△	×
		Crib Wall	○	○	△	×
		Gabion Wall	○	○	○	×
		Pile Wall	○	○	○	×
		Reinforced Soil Wall	○	○	○	×
	Catch Work	**Earth dyke (Catch Fill)**	×	△	○	×
		Catch Gabion	×	△	○	×
		Catch Concrete Wall	×	△	△	×
7. PILING WORK	Piling Work	Steel Pipe Pile	○	△	×	×
		H Steel Pile	△	△	×	×
		Shaft Work	○	△	×	×
8. PROTECTION WORK	Protection Work	Rock Fall Catch Net	△	△	○	×
		Rock Fall Catch Fence	△	△	○	×
	Rock Shed	Rock Shed	×	△	○	×
		Debris Shed	×	△	○	×
	Sabo (Check) Dam	Slit Dam	△	×	×	○
		Check Dam (Sabo Dam)	○	×	×	○
9. OTHERS	Avoiding Problem	Diversion (Shifting)	○	○	○	○
		Relocation	○	○	○	○

○ : Applicable △ : Limited case × : Not applicable

LS : Landslide **SF** : Slope failure **RF** : Rock Fall **DF** : Debris Flow

Bold type letter shows the countermeasures installed in the pilot projects.

Source: Modified from DESIGN GUIDE - EARTHWORKS, Published by Japan Highway Public Corporation, May, 1998.

4. Selection of countermeasures for landslides

Countermeasures for landslides belong to one of two broad categories, (A) control works; and (B) restraint works. Control works involve modifications to natural conditions such as, topography, geology, groundwater, or other conditions that indirectly control portions of the entire landslide movement. Restraint methods rely directly on the construction of structural elements. When the potential landslide is large-scale, it may be more cost-effective to relocate the route or building, etc.

Table 2.2 Classification of Countermeasures against Landslides

CLASSIFICATION			TYPE OF WORK
CONTROLE WORK	1. EARTH WORK	Earth Work	Cutting (Excavation)
			Filling (Embankment)
	2. VEGETATION	Vegetation	Hydro seeding
			Re-Vegetation
	3. WATER DRAINAGE	Surface Drainage	**Drainage Ditch**
			Culvert
		Subsurface Drainage	**Horizontal Drainage Drilling**
			Drainage Well
			Drainage Tunnel
RESTRAINT WORK	4.SLOPE WORK	Crib Work	Crib Work
	5. ANCHORING	Anchoring	Rock Bolt (Soil Nail)
			Ground Anchor
	6. WALL AND RESISTING STRUCTURES	Retaining Wall	Gabion Wall
			Retaining Wall
	7. PILING WORK	Piling Work	Steel Pipe Pile
			Shaft Work for Resistance Slide
9.OTHERS		Avoiding Problem Work	Diversion (shifting)
			Route Relocation
			Bridge, Tunnel
			Relocation of buildings, etc.

Bold type letter shows the countermeasure installed in the pilot projects.
Source: Modified from Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009

Figure 2.1 shows a flowchart for selection of countermeasures against landslides. Adequate works should be selected in consideration of the following points.

1) The works selected should address the mechanism(s) of the landslide, the relationship between precipitation, groundwater and landslide movement, geological, topographical and soil properties, the scale and type of landslide and its likely movement velocity.

2) Control works should be regarded as the main method of landslide control, while restraint works should be adopted for the stabilization of small landslides to directly protect public facilities, houses, etc.
3) Where landslide movement is closely related to rainfall, surface drainage work should be immediately performed to minimise the infiltration of rainwater.
4) When a landslide continues to move, control works should be performed first; restraint works can then be done after reduction or arresting the landslide movement by the control works.
5) An adequate combination of various works is cost-effective and should be selected.

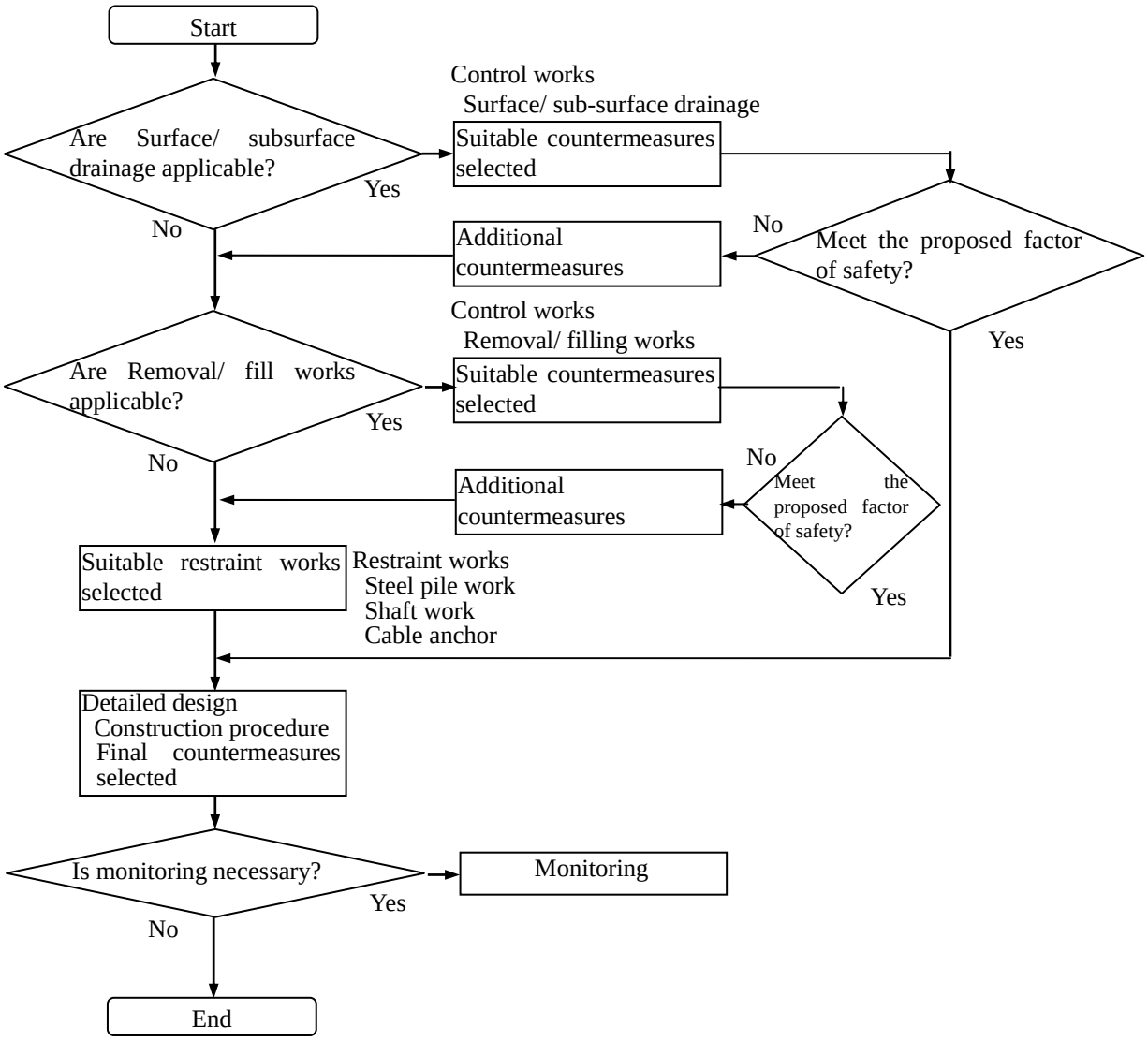


Figure 2.1 Flow chart for selection of countermeasures against landslides

Source: Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009

5. Selection of countermeasures for slope failures

Heavy rainfall frequently causes collapses in steep slopes. Many steep slopes are stable during normal conditions but become unstable during or after heavy rainfall. To prevent slope failures, either the sliding force must be decreased or sufficient resistance to overcome the sliding force must be added by structures. Any prevention plan should be suitable for the field conditions.

Table 3.3 shows the classification of countermeasures for preventing slope failures.

Table 2.3 Classification of Countermeasures against Slope Failures

CLASSIFICATION		TYPE OF WORK
1. EARTH WORK	Earth Work	Cutting
		Filling
2. VEGETATION	Vegetation	Hydroseeding
		Re-Vegetation
3. WATER DRAINAGE	Surface Drainage	Subsoil Drainage Hole (shorter)
		Drain Ditch and Cascade or Catch Pit
	Subsurface Drainage	Culverts
		Horizontal Drainage Drilling
4. SLOPE WORK	Pitching Work	Stone Pitching
	Shotcrete Work	Shotcrete (mortar)
		Shotcrete (concrete)
	Crib Work	Crib work (Precast)
5. ANCHORING	Anchoring	**Soil Nail** (Rock Bolt)
		Ground Anchor
6. WALL AND RESISTING STRUCTURES	Retaining Wall	Gabion Wall
		Stone Pitching Wall
		Concrete Block Wall
		Retaining Wall (Supported Type)
	Catch Work	Catch Concrete Wall
7. PILING WORK	Piling Work	Steel Pipe Pile
		H Steel Pile

Bold type letter shows the countermeasure selected in the pilot project.
Source: Modified from MANUAL FOR COUNTERMEASURE WORKS AGAINST SLOPE FAILURE, Japan Sabo Association, July 1996

Figure 3.2 shows a flow chart for the selection of countermeasures to prevent slope failures. An adequate and effective measure for preventing slope failures should be selected in consideration of the anticipated causes, shape, mechanism, and scale of failure, as well as appearance and through discussion. Generally, the following criteria must be used for selection.

1) Wherever possible, cutting work should be selected, especially in the case of overhanging slopes and highly jointed or weathered rock slopes. In planning

cutting work, slope stability and harmony with the surrounding environment should be considered.

2) In principle, surface drainage work should be planned positively. Subsurface drainage works should be adopted if spring water exists during the normal time and/or rainfall, or a depression exists near the top of the slope.
3) In most cases, vegetation is low-cost, if it is an available option (gradient and soil). Vegetation should be applied to prevent erosion due to rainfall by growing plants on the face of the slope. Where slopes are unsuited to vegetation, such as jointed or weathered rock slopes, pitching work, shotcrete work, and crib work should be considered.
4) Retaining wall works should be selected if the foot of a slope must be stabilized or if it is to be used as the foundation of other measures.
5) Even though they are costly, anchoring or piling works should be planned if other methods are not expected to control collapses.

The success of such prevention measures is influenced greatly by topographical, geological and meteorological conditions. In principle, cutting work, drainage work, retaining walls and vegetation are the preferable choices. Structural methods such as crib work and anchor work are adopted only when soil and gradient conditions are unsuitable for vegetation and slope stability cannot be secured by cutting and/or drainage works alone.

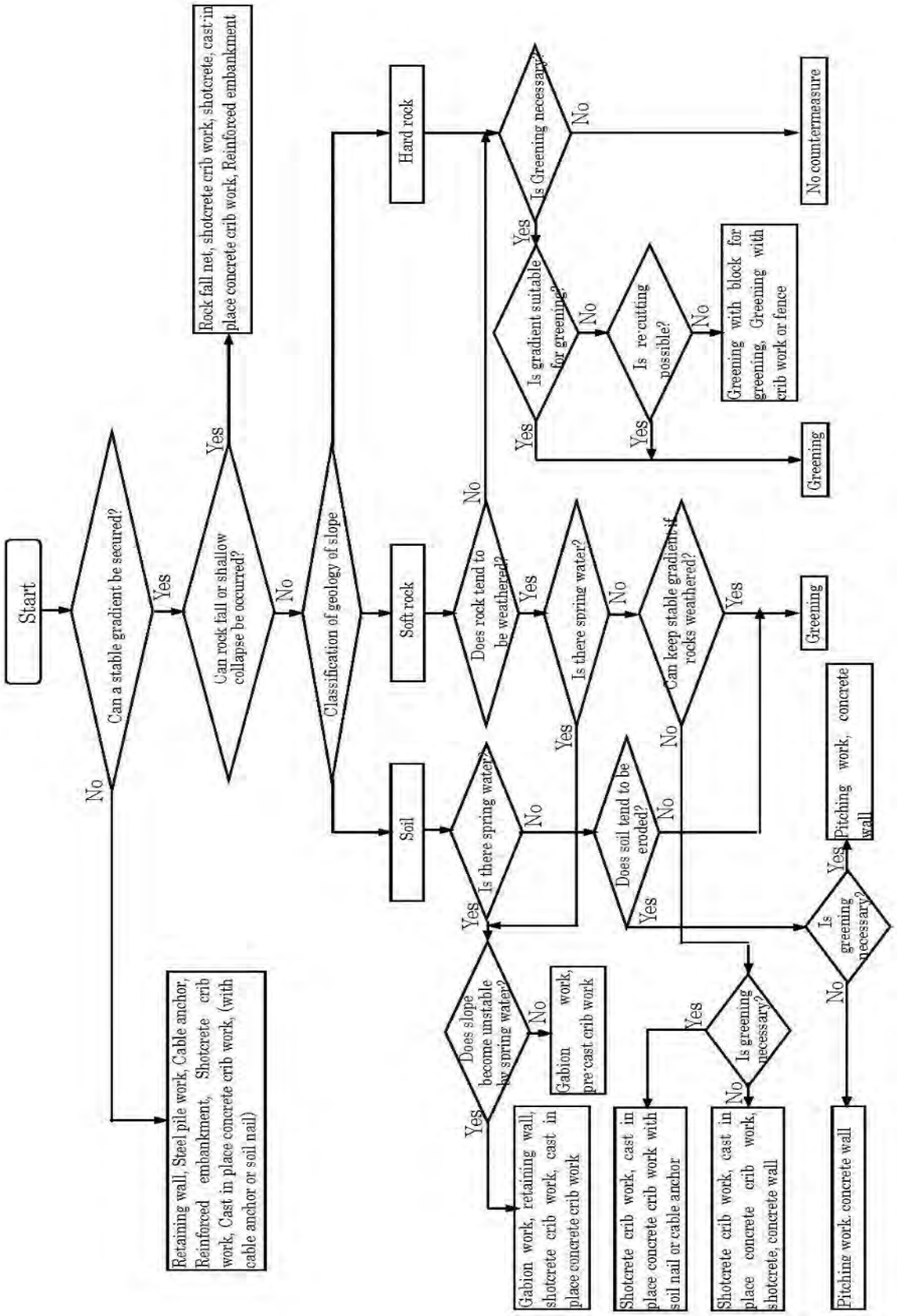


Figure 2.2 Flow chart for selection of countermeasures against slope failures

Source: Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009

6. Selection of countermeasures for Rock Fall

Heavy rainfall, earthquakes and freezing/ thawing frequently cause rock fall. In Sri Lanka, only it might not be necessary to consider earthquakes, freezing and thawing. Countermeasures against rock fall are classified into two categories, A: Rock Fall Mitigation Works and B: Rock Fall Protection Works.

Rock fall mitigation works are countermeasures for the source of the rock fall. The mitigation works are generally to cut or remove the source of the rock fall, or fix the source of rock fall by foot protection, rock bolt or cable anchor. The purpose of the rock fall mitigation works are the following;

1) Mitigation of weathering caused by such things as surface water, freezing and thawing, alteration of temperature, wet-dry cycle and wind-force, etc.
2) Possible rock fall source materials should be directly prevented in situ.
3) Possible rock fall source materials should be removed or cut.
4) Rock fall caused by slope failure should be prevented.

Rock fall protection works are countermeasures for protection of objects to be preserved. The protection works are generally to construct a fence, wall or earth dyke in front of the objects to be preserved, or install steel wire net onto rock fall prone slopes. The rock fall protection works consist of two (2) types as following based on the location of installation.

a) Countermeasures installed slopes from the source of the rock fall to the objects to be prevented are cutting, removing, rock fall protection steel wire net, shotcreting and rock fall protection retaining wall, etc.

b) Countermeasures installed in front of the objects to be preserved are rock fall protection steel wire net, rock fall protection shelf, rock fall protection retaining wall, rock shed and rock fall protection earth dyke/ ditch, etc.

Any mitigation plan should be adequate for site conditions. Table 2.4 shows the classification of countermeasures against rock fall and Figure 2.3 shows the flow chart for selection of countermeasure works against rock falls.

Table 2.4 Classification of Countermeasures against Rock Fall

CLASSIFICATION	TYPE OF WORK
Rock Fall Mitigation Works	Cutting
	Removal Works
	Foot Protection
	Gluing Works
	Ground Anchor
	Wire Rope
	Drainage Works
	Wicker Works
	Planting
	Shotcrete
	Pitching

	Crib Works
	Retaining Wall
	Rock Fall Protection Works + Rock Bolt
	Shotcrete + Rock Bolt
	Pitching + Rock Bolt
	Crib Works + Rock Bolt
	Crib Works + Cable Anchor
	Retaining Wall + Cable Anchor
Rock Fall Protection Works	Cover Type Rock Fall Protection Steel Wire Net
	Pocket Type Rock Fall Protection Steel Wire Net
	Rock Fall Protection Fence
	Multiple Step Rock Fall Protection Fence
	Rock Fall Protection Shelf
	Rock Fall Protection Retaining Wall
	Rock Shed
	Rock Fall Protection Earth Dyke/ Ditch

Bold type letter shows the countermeasure installed in the pilot projects.

Source: MANUAL FOR COUNTERMEASURES AGAINST ROCK FALL, Published by Japan Road Association, June 2000.

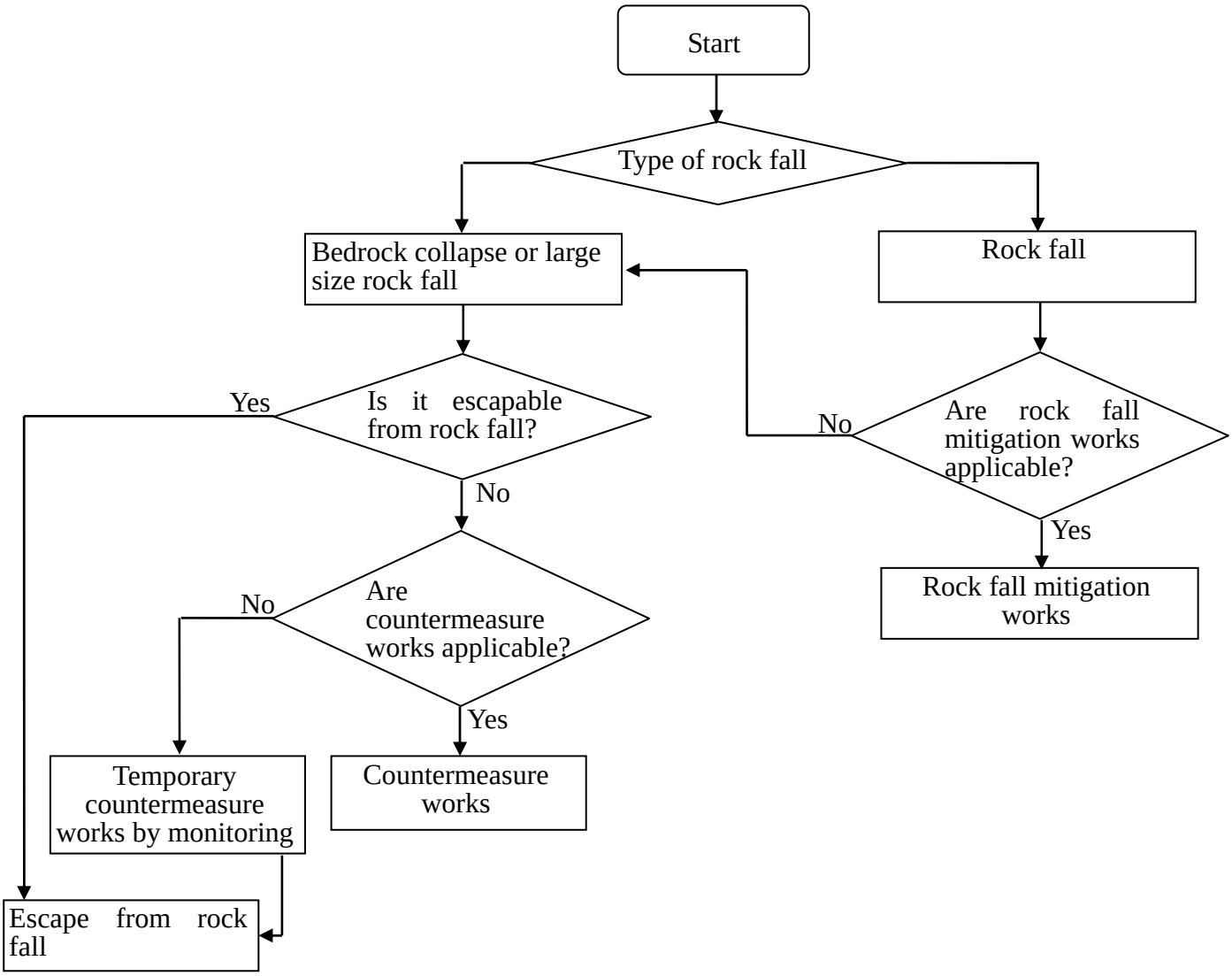


Figure 2.3 Flow chart for selection of countermeasures against rock falls

Source: MANUAL FOR COUNTERMEASURES AGINST ROCK FALL, Published by Japan Road Association, June 2000.

CHAPTER 3 DESIGN CONSIDERATION OF TYPICAL COUNTERMEASURES

1. General

In designing countermeasures against landslides/ sediment disaster, adequate considerations shall be made to ensure that the proposed countermeasures may be carried out safely, effectively and in an appropriate manner.

In designing countermeasures, it is most important to understand the mechanism of the landslides/ sediment disaster. Countermeasures against landslide/ sediment disaster should be different according to types of landslides/ sediment disaster. Based on the classifications of landslides/ sediment disaster, adequate countermeasures should be proposed.

Regarding general matters such as stability analysis, there are some existing manuals in Sri Lanka. These manuals cover general matters described in Japanese manuals. Therefore this chapter presents information and know-how based on the experiences of the TCLMP.

2. Design Considerations of Typical Countermeasures

2.1. Cutting Works (Excavation)

(1) Purpose

Cutting work is applied to remove unstable soil and rock and to reduce the load, and hence shear force, at the head of an unstable or potentially unstable slope.

(2) Design Considerations

The gradient and vertical height of the cutting slope should be determined on the basis of the geological conditions, etc. The gradient should be between 1V to 0.3H and 1V to1.5H depending on subsurface conditions and characteristics (Table 3.1). Berms 1 to 4 m wide should be created at intervals of 5 to 10 m in the vertical direction. Careful investigation of the stability of the back slope should be conducted prior to cutting. This suggestion is shown only in the normal gradient, therefore the applied gradient should be approved by the Engineer.

In designing a cut slope, the following geological conditions should be considered with the utmost care.

1) Colluvial deposit slope

   Colluvium such as talus, landslide deposits and debris flow deposits, being poorly consolidated, usually forms a slope with a critical angle of stability. When excavated, the cut slope formed will become unstable. For this reason, a wide berm near the boundary between the bedrock and the upper colluvial deposit should be designed. Especially, extreme care should be paid for cutting or excavation in potential landslide areas. In potential landslide areas, more than three (3) m slope length excavation or two (2) m height

excavation should require approval by the Engineer with submission of a proposal for countermeasure works.

2) Erosive sandy soil

Sandy soils, such as disintegrated granite and terrace gravel, are easily eroded by surface water resulting in small shallow collapse.

3) Erodible soft rocks

Cut slopes of soft rocks such as heavily weathered rocks or fractured rocks sometimes become unstable after the completion of cutting because of the weak internal strength of the rock and stress release.

4) Fractured rock slope

The stability of fractured rock slopes is governed by the degree of fissure development and their distribution.

Table 3.1 Geometric Suggestion of Cutting Slopes

Character of soil or bedrock		Height (m)	Gradient (i =V:H)
Hard rock			1:0.3 ~ 1:0.8
Soft rock			1:0.5 ~ 1:1.2
Sand	Those not dense, not solid and of bad grade distribution.		1:1.5 ~
Sandy soil	Those are dense and solid.	Less than 5 m	1:0.8 ~ 1:1.0
		5~10 m	1:1.0 ~ 1:1.2
	Those not dense, not solid.	Less than 5 m	1:1.2 ~ 1:1.5
		5~10 m	1:1.5 ~ 1:1.8
Sandy soil mixed with gravel or rock mass	Those are dense and solid or of good grade distribution	Less than 10 m	1:0.8 ~ 1:1.0
		10~15 m	1:1.0 ~ 1:1.2
	Those not dense, not solid or of bad grade distribution.	Less than 10 m	1:1.0 ~ 1:1.2
		10~15 m	1:1.2 ~ 1:1.5
Residual soil		Less than 10 m	1:1.5 ~ 1:1.8
Cohesive soil mixed with rock mass or cobble stones		Less than 5 m	1:1.0 ~ 1:1.2
		5~10 m	1:1.2 ~ 1:1.5
Landslide deposit	Deposit in potential landslide area	Less than 2m Slope length: less than 3m	1:1.0 ~ 1:1.2
		More than 2m height or 3m slope length: Approval for adequate countermeasures by the Engineer should be required.	

Note1: This table is only a preliminary suggestion. Further detailed analysis should be carried out by an engineer.

Note2: Silt is placed under cohesive soil. Individual consideration is given to soils not be indicated in the table.

Source: No.2 Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009.

To prevent erosion of the cutting natural slope, protection of the slope and the foot of slope should be considered. Slopes should be protected by a retaining wall or soil nailing when it is unavoidable to form a cut slope with a gradient steeper than the standard gradient.

2.2. Filling Work (Embankment)

(1) Purpose

Filling work is used at the toe of unstable or potentially unstable slopes to balance the driving force of additional loading.

(2) Design considerations

The main considerations for embankments chiefly concern stability analysis as well as the selection of slope gradient in proportion to fill materials. In selecting fill materials, their strength and deformation characteristics should be considered. Table 3.2 gives the recommended standard fill slope for different fill materials. These can only be applied where the foundation ground has sufficient bearing capacity.

Table 3.2 Recommended Standard Fill Slopes

Fill Materials	Height (m)	Gradient (V:H)
Well graded sand, gravels and sand or silt mixed with gravels (GW, GP, GM, GC)	Less than 5 m	1:1.5 ~ 1:1.8
	5 ~ 15 m	1:1.8 ~ 1:2.0
Poorly graded sand (SP).	Less than 10 m	1:1.8 ~ 1:2.0
Rock masses (including muck).	Less than 10 m	1:1.5 ~ 1:1.8
	10 ~ 20 m	1:1.8 ~ 1:2.0
Sandy soils (SM, SC), hard clayey soil and clays (CL, ML).	Less than 5 m	1:1.5 ~ 1:1.8
	5 ~ 10 m	1:1.8 ~ 1:2.0
Soft clayey soils	Less than 5 m	1:1.8 ~ 1:2.0

Note) Height of fill is the vertical height from the toe to the top of the fill.
Source: Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009.

Furthermore, for high fills consisting of different kinds of materials, a standard gradient suitable to each material should be applied to each slope. The stability of the foundation ground of the fill should be reviewed prior to construction.

Especially embankments in potential landslide areas extreme care should be paid. If the height of the embankment is more than 2-3m, it would be better to discuss with the Engineer and acquire approval from the Engineer.

2.3. Surface Drainage Ditch

In most cases, surface water should be prevented from infiltrating the landslide areas to avoid any hydraulic thrusts. Especially where landslides are closely related to short-term rainfall, surface drainage work should be immediately performed regardless of the results

of stability analyses. A U-shaped gutter, centrifugal reinforced concrete or corrugated pipe may be used to construct the drainage ditch.

(1) Purpose

Surface drainage control includes works for drainage collection and drainage channels.

(2) Design Considerations

Surface drainage works are designed to collect surface flow by installing lined ditches along the slopes, which are then connected to a drainage channel. The drainage channel works are designed to remove the collected water out of the landslide zone as quickly as possible, and are constructed from the same materials as the surface drainage works. The surface drainage control works are often combined with subsurface control works.

The drainage ditch beds should, in principle, be covered. Water collecting pits should be installed at the confluence with tributaries, curves and points of change in gradient.

The shoulders and cut slope faces of the ditches must be protected with vegetation, boulder covers, and so on.

(3) Run off calculation

The cross section of the surface drainage ditch shall be designed based on the planned high-water discharge. The parameters for design can be obtained by the following methods. The catchment area is estimated by a map with a field survey. If Digital Elevation Model (DEM) data is available instead of map, it could be easier to measure the catchment area. The design rainfall amount shall be estimated using past rainfall data. In the project, 150mm/hr was used because past rainfall data was insufficient. However, in the future, rainfall data should be recorded and utilized for run off calculation.

The process of calculation is shown in Figure 3.1 as a flowchart. The process of run off calculation is shown below.

- ✓ Assumption of reaching time from the upper stream (At this stage, discharge has not been calculated yet, so calculation of flow time is impossible. Therefore the time should be an assumption at this stage.)
- ✓ The probable rainfall rate should be determined. (As described above, 150mm/hr was used in the project)
- ✓ Based on the probable rainfall rate, planned peak discharge is calculated.
- ✓ Reaching time is calculated again based on the planned peak discharge. Reaching time should be checked with assumed reaching time. If the difference is too large, assumption of the reaching time should be given again and recalculated. If the assumed reaching time is smaller than the calculated reaching time, the calculation can be finished in principle. It is recommended that the difference between the assumed reaching time and calculated reaching time be smaller than 20%.

The formula for rational runoff and parameters for Badurusiligama are shown below as an example. The flow chart of run off calculation is shown in Fig 3.1.

Rational formula (Natural flow by rainfall)

$Qp=C\times(1/3.6)\times r\times A$

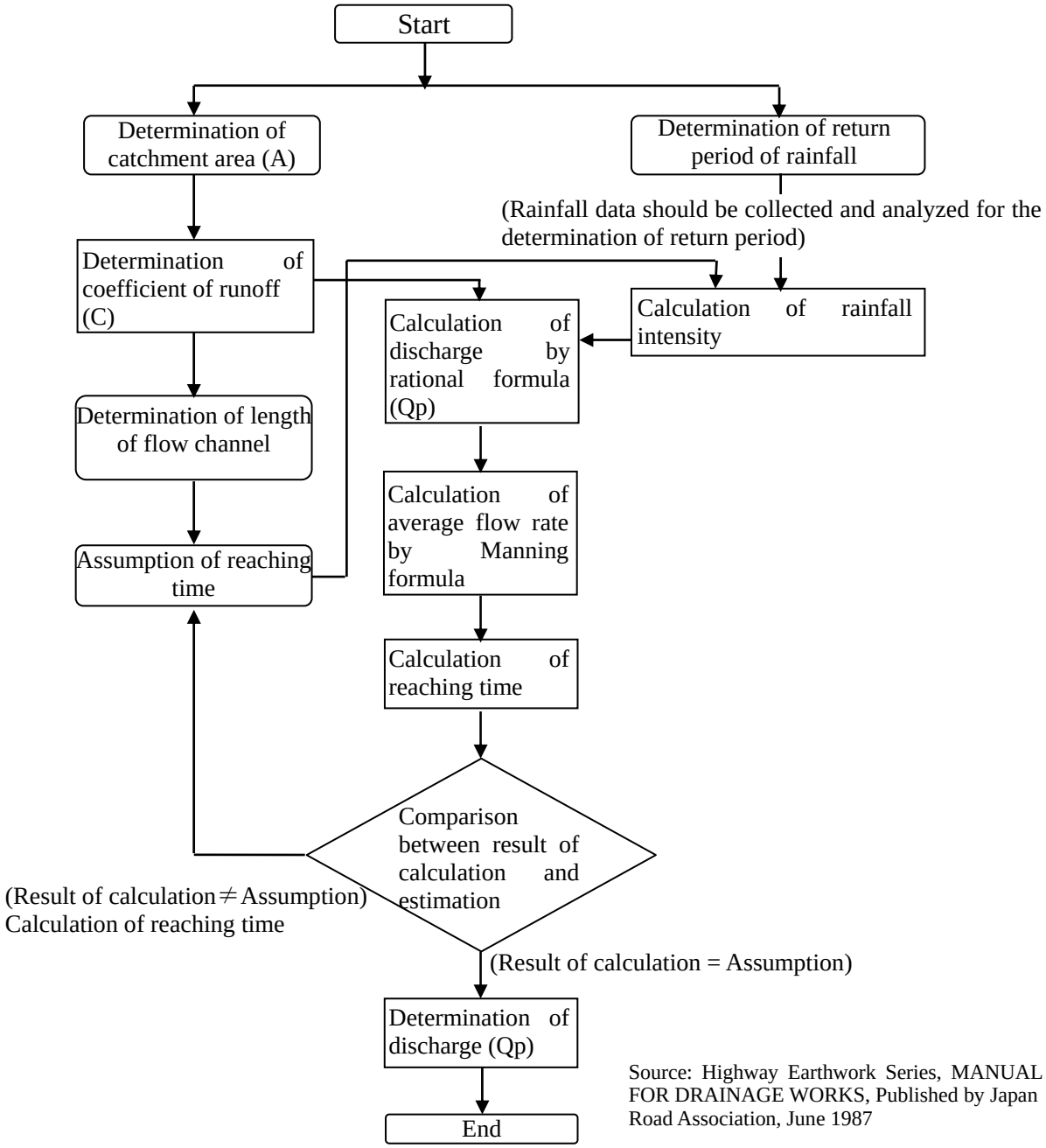
Qp: Peak Discharge (m3/s)

C: Coefficient of Runoff (mountain area 0.8)

r: Probable Rainfall Rate in reaching time (Estimate 150mm/hr)

A: Catchment Area (0.196km2)

$Qp=0.8\times(1/3.6)\times 150\times 0.196=6.533$m3/s



Source: Highway Earthwork Series, MANUAL FOR DRAINAGE WORKS, Published by Japan Road Association, June 1987

Figure 3.1 Flow chart of run off calculation

The runoff coefficient (C) is a dimensionless coefficient relating the amount of runoff to the amount of precipitation received. It is a larger value for areas with low infiltration and high runoff (pavement, steep gradient), and lower for permeable, well vegetated areas (forest, flat land).

It is important for flood control channel construction and for possible flood zone hazard delineation. A high runoff coefficient (C) value may indicate flash flooding areas during storms as water moves fast overland on its way to a river channel or a valley floor.

It is measured by determining the soil type, gradient, permeability and land use. The values are taken from the table below. The larger values correspond to higher runoff and lower infiltration.

Table 3.3 Runoff coefficient

Land Use (soil type, gradient)	C	Land Use (soil type, gradient)	C
Business:		Lawns:	
Downtown areas	0.70-0.95	Sandy soil, flat, 2%	0.05-0.10
Neighbourhood areas	0.50-0.70	Sandy soil, avg.,2-7%	0.10-0.15
		Heavy soil, flat,2%	0.13-0.17
		Heavy soil, avg.,2-7%	0.18-0.22
		Heavy soil, steep,7%	0.25-0.35
Residential:		Agricultural land:	
Single-family areas	0.30-0.50	Bare packed soil	
Multi units, detached	0.40-0.60	*Smooth	0.30-0.60
Multi units, attached	0.60-0.75	*Rough	0.20-0.50
Suburban	0.25-0.40	Cultivated rows	
		*Heavy soil, no crop	0.30-0.60
		*Heavy soil, with crop	0.20-0.50
		*Sandy soil, no crop	0.20-0.40
		*Sandy soil, with crop	0.10-0.25
		Pasture	
		*Heavy soil	0.15-0.45
		*Sandy soil	0.05-0.25
		Woodlands	0.05-0.25
Industrial:		Streets:	
Light areas	0.50-0.80	Asphaltic	0.70-0.95
Heavy areas	0.60-0.90	Concrete	0.80-0.95
		Brick	0.70-0.85
Parks, cemeteries	0.10-0.25	Unimproved areas	0.10-0.30
Playgrounds	0.20-0.35	Drives and walks	0.75-0.85
Railroad yard areas	0.20-0.40	Roofs	0.75-0.95

Note: The designer must use judgment to select the appropriate "C" value within the range. Generally, larger areas with permeable soils, flat slopes and dense vegetation should have the lowest "C" values. Smaller areas with dense soils, moderate to steep slopes, and sparse vegetation should assigned the highest "C" values.
(Source: http://water.me.vccs.edu/courses/CIV246/table2b.htm)

If land uses are not simple, the weighted average efficiency based on the area ratio (Pi) should be used.

$C = \Sigma (Pi \times Ci)$

Average flow rate is calculated by the Manning formula and roughness coefficient shown below. The roughness coefficient should be studied for Sri Lanka.

Manning Formula (Capacity flow of water drainage)

Q = A×V

Q: Capacity of Flow (m3/s)

A: Flow Section (m2) depends on the height

V: Velocity (Average flow rate) (m2/s)

V = (1/n) R (2/3) × I(1/2)…Manning formula

V: Velocity (Average flow rate) (m2/s)

n: Coefficient of Roughness (0.015)

R: Hydraulic depth in the water way (0.355m)

I: Gradient (10.1%)

Q = A × V = 0.734 × 10.62 = 7.79m3/s ≧ Qp (6.533)・・・・ OK

Table 3.4 Roughness coefficient

Surface Material	**Manning's Roughness Coefficient- *n* -**
Asbestos cement	0.011
Asphalt	0.016
Brass	0.011
Brick	0.015
Canvas	0.012
Cast-iron, new	0.012
Clay tile	0.014
Concrete - steel forms	0.011
Concrete (Cement) - finished	0.015*
Concrete - wooden forms	0.015
Concrete - centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Earth, smooth	0.018
Earth channel - clean	0.022
Earth channel - gravelly	0.025
Earth channel - weedy	0.030
Earth channel - stony, cobbles	0.035
Floodplains - pasture, farmland	0.035
Floodplains - light brush	0.050

Surface Material	Manning's Roughness Coefficient- *n* -
Floodplains - heavy brush	0.075
Floodplains - trees	0.15
Galvanized iron	0.016
Glass	0.010
Gravel, firm	0.023
Lead	0.011
Masonry	0.025
Metal - corrugated	0.022
Natural streams - clean and straight	0.030
Natural streams - major rivers	0.035
Natural streams - sluggish with deep pools	0.040
Natural channels, very poor condition	0.060
Plastic	0.009
Polyethylene PE - Corrugated with smooth inner walls	0.009 - 0.015
Polyethylene PE - Corrugated with corrugated inner walls	0.018 - 0.025
Polyvinyl Chloride PVC - with smooth inner walls	0.009 - 0.011
Rubble Masonry	0.017
Steel - Coal-tar enamel	0.010
Steel - smooth	0.012
Steel - New unlined	0.011
Steel - Riveted	0.019
Vitrified Sewer	0.013 - 0.015
Wood - planed	0.012
Wood - unplaned	0.013
Wood stove pipe, small diameter	0.011 - 0.012
Wood stove pipe, large diameter	0.012 - 0.013

Source: Modified from https://www.engineeringtoolbox.com/mannings-roughness-d_799.html

* This parameter is from Japanese standard, Highway Earthwork Series, MANUAL FOR DRAINAGE WORKS

2.4. Horizontal Drainage Drilling

Groundwater can generally be divided into two types, shallow and deep. Shallow groundwater, 0 to 5 meters below the ground surface, is due mainly to rainfall received in the short-term. Shallow groundwater frequently causes a shallow failure or the toe failure of a large-scale unstable slope. In such cases, culverts and horizontal drain holes are effective. Deep groundwater is related to rainfall received over the longer term and should be drained by installation of drainage wells or tunnels with horizontal drain drillings. The following is a brief presentation of considerations for horizontal drain

drillings and drainage wells as these are the most effective methods of stabilizing landslides.

(1) Purpose

Horizontal drain drillings are used to drain both shallow and deep groundwater to stabilize the landslide by decreasing the pore water pressure that is responsible for activating the slip surface. It is useful as a temporary countermeasure to decrease the moving speed of a landslide.

If necessary, the designed reduction in the groundwater level may be determined through stability calculations, aiming at achieving the following values in the case of the standard-scale landslide with a slip surface depth of 20 metres according to the manual in Japan.

- Horizontal drain 1 to 3 meters
- Drainage well 3 to 5 meters
- Drainage tunnel 5 to 8 meters

(2) Design Considerations

Horizontal drainage drillings are constructed for the drainage of the shallow groundwater and deep groundwater. If topography prevents the groundwater from being drained on a gentle gradient, then drainage wells or tunnels with horizontal drainage drillings should achieve drainage.

Horizontal drain drillings, usually 20 to 50 meters in length, should be drilled at a gradient of 5 to 10 degrees with a diameter of 50 to 100 millimetres and should be designed to traverse aquifers. The horizontal drillings should penetrate the slip surface from 5 to 10m. And the end of the drillings, the spacing of drillings should be 5-10m. Typical locations of horizontal drainage drillings are shown in Figure 3.2.

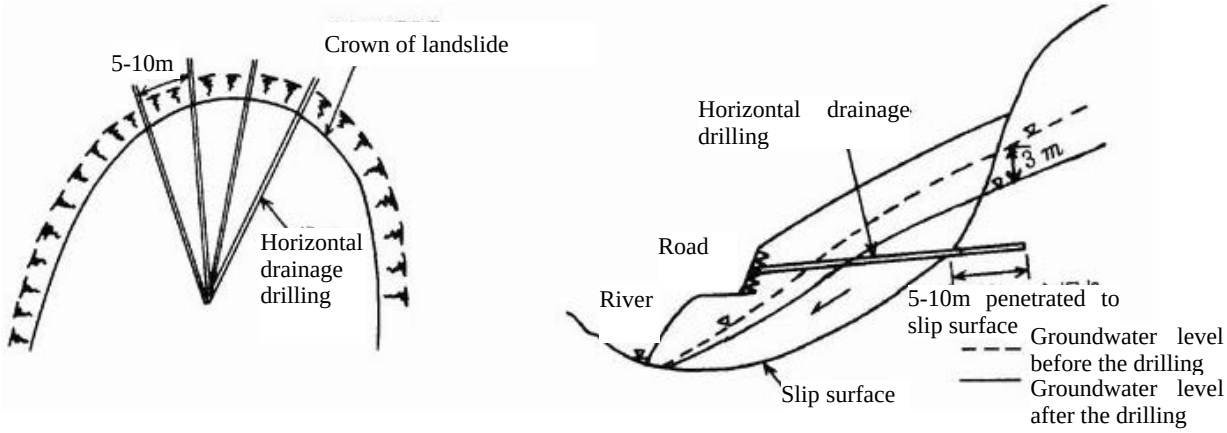


Figure 3.2 Typical locations of horizontal drainage drillings

Source: Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009.

2.5. Earth Dyke/ Ditch for Rock Fall

(1) Purpose

Earth dyke/ ditch are one of rock protection works to absorb and dissipate rock fall energy. If there is enough land for constructing an earth dyke/ ditch, this countermeasure is applicable. Also earth dyke/ ditches are quite simple countermeasures with excavation and embankment, and they are quite inexpensive. However, if there are a lot of fallen rocks in the land for constructing an earth dyke/ ditch, sometimes rock blasting works should be conducted for excavation. In this case, the cost might be expensive for the blasting. However, blasted rocks can be used for materials for gabion works and pitching works of the surface of the earth dyke.

The characteristics of the earth dyke/ ditch are shown below.

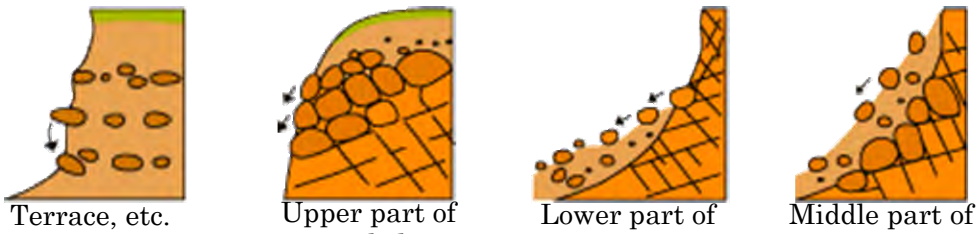
a) It is inexpensive because soil generated by excavation or cutting can be used for materials of embankment.
b) Enough land for earth dyke/ ditch should be required.
c) The land for earth dyke/ ditch should be stable.
d) The earth dyke/ ditch can change direction of rock falls and lead rock falls to empty land according to topography.

(2) Design Consideration

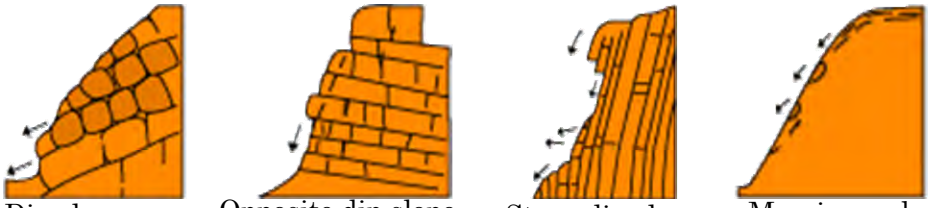
a) Type of rock fall

The type of rock fall is classified into three types, 1) rock fall from debris and weathered rock, 2) bedrock collapse and 3) others. These types have different mechanisms, predisposition and triggers. Therefore the classification of rock fall types should be premises of judgement of possibility of rock falls and selection of countermeasure types. Typical rock fall types are shown below.

1) Rock fall from debris and weathered rock



2) Bedrock collapse



Source: modified from http://isabou.net/theme/03-01_rakuseki/knowledge/index.asp

b) Main trigger of rock fall and their effect

The main trigger of rock falls is complicated and some triggers might cause rock falls. Therefore it would be difficult to clarify triggers of rock falls. Main triggers of rock falls are shown in Table 3.5.

Table 3.5 Main triggers of rock fall

Trigger	Effect
Rainfall	Weakening and erosion of ground surface caused by snow melting, surface stream water, spring water, and seepage water
Accumulated snow	Erosion caused by movement of snow, etc. (e.g. glacial erosion)
Freeze-thaw	Widening of cracks, exfoliation by freeze of water, and weakening of ground caused by movement of groundwater
Strong wind	Exfoliation and destabilization of rolling stone caused by sway of tree
Earthquake	Destabilization of loose rocks and slope
Vegetation	Widening of cracks and exfoliation caused by growth of tree root
Artificial	Destabilization of rolling stone by trampling, destabilization of slope due to installation of structures, acceleration of destabilization of slop due to overflow and leakage from ditch, and defect of drainage facility.

Source: http://isabou.net/theme/03-01_rakuseki/knowledge/index.asp

c) Type of rock fall movement

Types of rock fall movements are 1) slide, 2) rotation and 3) bounce. Types of rock fall movement should be considered for planning of countermeasure works. Applicable countermeasure works should be selected and location, area, height and structure of countermeasure works should be designed based on the types of rock fall movement.

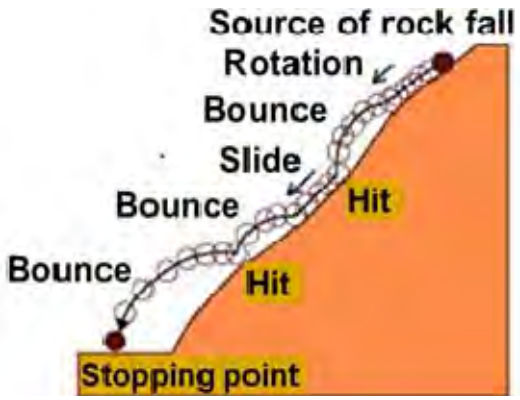
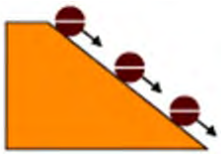
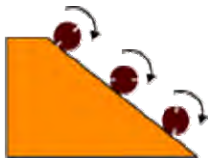
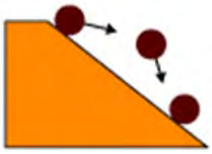


Figure. 3.3 Schematic diagram of rock fall movement

Source: http://isabou.net/theme/03-01_rakuseki/knowledge/index.asp

Table 3.6 Type of rock fall movement and description

Type of Movement		Description
Slide		Masses of rock, boulders and gravels slide down along the slope.
Rotation		Masses of rocks, boulders and gravels move down with rotation along the slope.
Bounce		Rocks move with bouncing in the air: 1) Movement with bouncing on the ground or trees. 2) Sometimes rock falls without bouncing from the source of the rock fall to the stopping point such as road or structure.

Source: http://isabou.net/theme/03-01_rakuseki/knowledge/index.asp

d) Fallen rock survey

Distribution of fallen rocks in the target area should be surveyed and to identify the location of fallen rocks. At the same time sizes and shapes of fallen rocks should be recorded on a map and a table. The location and area of countermeasure works should be designed based on the results of a fallen rock survey.

Fig. 3.4 shows an example of a fallen rock survey in Matale.

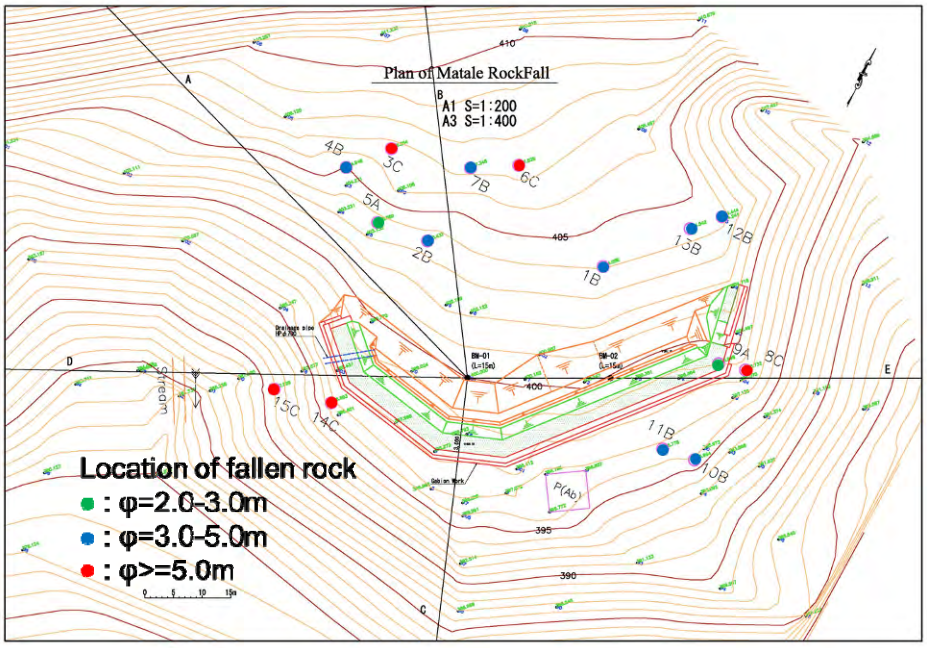


Figure 3.4 Example of fallen rock survey in Matale (Source: JICA Consultant Team)

e) Rock fall Simulation

If rock fall protection works are selected, it would be better to conduct a rock fall simulation in order to estimate the rock fall energy and height of bounce. According to results of field experiments in Japan, the height of the bounce is changed depending on slope conditions. It is important to estimate the height of the bounce, especially to estimate if a higher bounce will occur or not. Based on the result of simulation, location, size and height of countermeasure works should be designed. However, at the moment there is no simulation software in Sri Lanka in English. Therefore a procedure of simulation is shown below in Fig. 3.5.

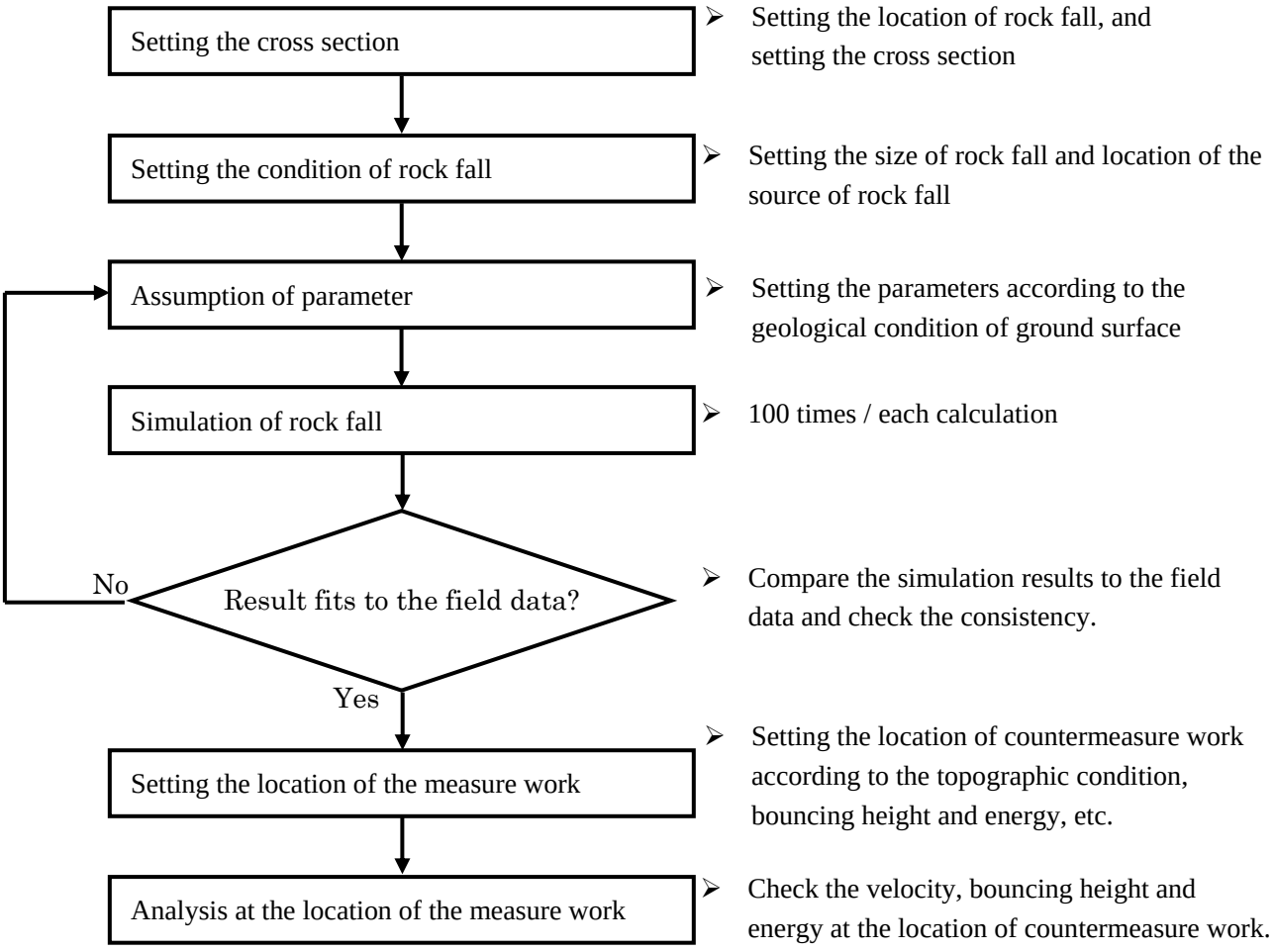


Figure 3.5 Flow chart of rock fall simulation

Source: MANUAL FOR ROCK FALL SIMULATION, Godai Kaihatsu Corporation

f) Height of bounce of rock fall

As described in e), to estimate the height of bounce of rock fall is quite important in order to design the height of rock fall protection measures. Fig. 3.6 shows results of field experiments and rock fall simulation. In the figure, relationships between heights of bounce (h: vertical height from the ground) and drop height (H: height from the dropping

point) are shown. Continuous lines in the figure shows a 90% envelope curve in each data. In the field experiments, the highest bounce height is 5.7m, and more than 2m bounce height is 16% of the whole data. On the other hand, based on the result of the simulation, the highest bounce is 6.2m and more than 2m bounce height is 9% of the whole data. Therefore in the Japanese standard, 2m bounce height is usually used as a standard. Of course based on the simulation results, if the bounce height is more than 2m, the height of countermeasure works should be designed depending on the simulation results.

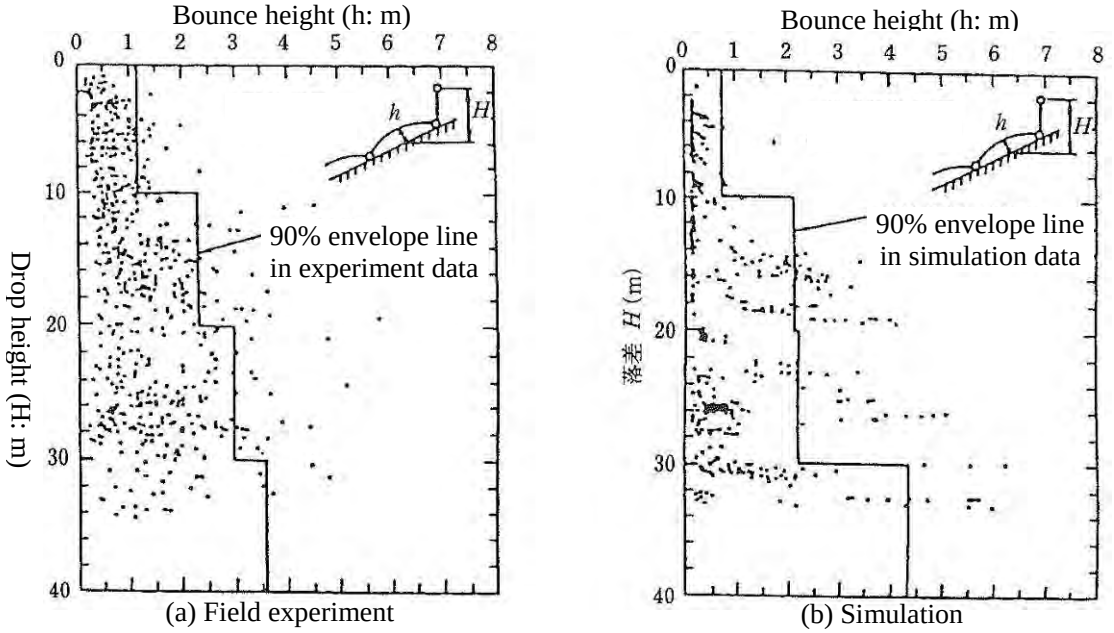


Figure 3.6 Relationships between bounce height and drop height

Source: MANUAL FOR COUNTERMEASURES AGINST ROCK FALL, Published by Japan Road Association, June 2000.

g) Design of earth dyke/ ditch

As mentioned above, the earth dyke/ ditch is installed in order to absorb and dissipate rock fall energy at the slope of the earth dyke or bottom of the ditch. If there is a gentle slope at the middle of the target slope, fallen rocks on the gentle slope can be used for gabion works or pitching works on the surface of the earth dyke. In this case, not only the stability of the earth dyke on the gentle slope should be checked but also the stability of the slope after the completion of the earth dyke.

It is better to avoid installation of an earth dyke/ ditch at the area of surface water flow could be concentrated, in a small stream and spring water. If it is impossible to install at the areas above, drainage works should be installed together with the countermeasures and extreme care for maintenance and management should be required.

A rough indication of the range of application for the countermeasure works against rock fall is shown in Fig. 3.7 for reference. According to the figure, an earth dyke is applicable in the approximate range from 300kJ to 4,000kJ.

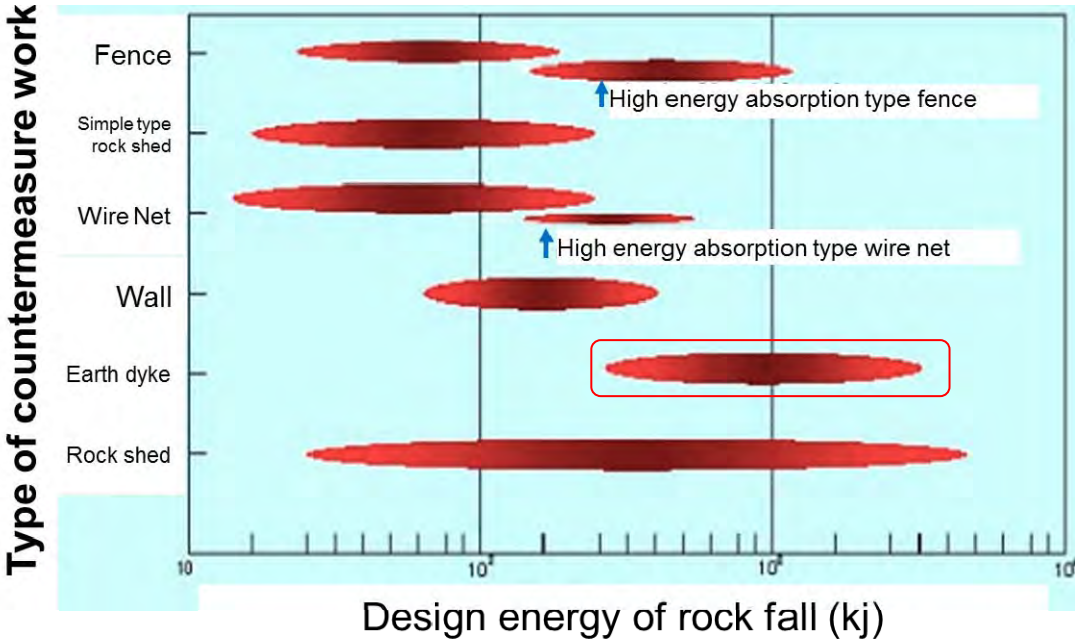
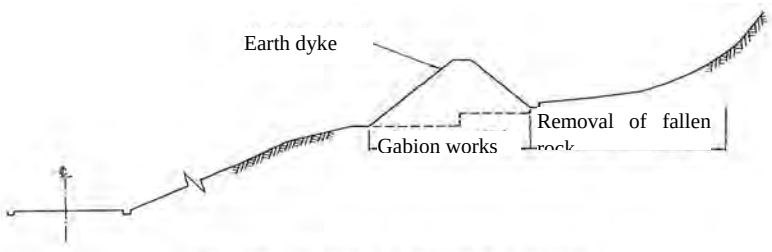


Figure 3.7 Rough indication of range of application for the countermeasure works against rock fall

Source: MANUAL FOR COUNTERMEASURES AGINST ROCK FALL, Published by Japan Road Association, June 2000.

Fig 3.8 shows examples of earth dyke/ ditches on a gentle slope. As mentioned above, most of the bounce height of the rock fall is less than 2m. Therefore, the height of the dyke and the depth of ditch should be more than 2m. In most cases, 2m might be enough according to the result of field experiment and simulation.

An example of a ditch on a gentle slope



An example of an earth dyke on a gentle

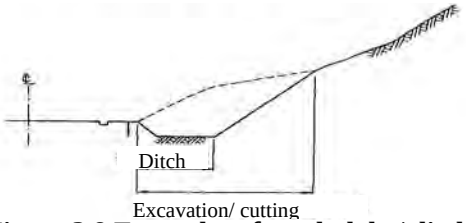


Figure 3.8 Examples of earth dyke/ ditch

Source: MANUAL FOR COUNTERMEASURES AGINST ROCK FALL, Published by Japan Road Association, June 2000.

Fig 3.9 shows the design of an earth dyke/ ditch in the pilot project site at Alagumale in Matale. This is combination of earth dyke and ditch and the height is more than 2m. If the design condition is almost the same as this pilot site, this cross section is applicable for most of the rock fall prone areas with enough land for the measures.

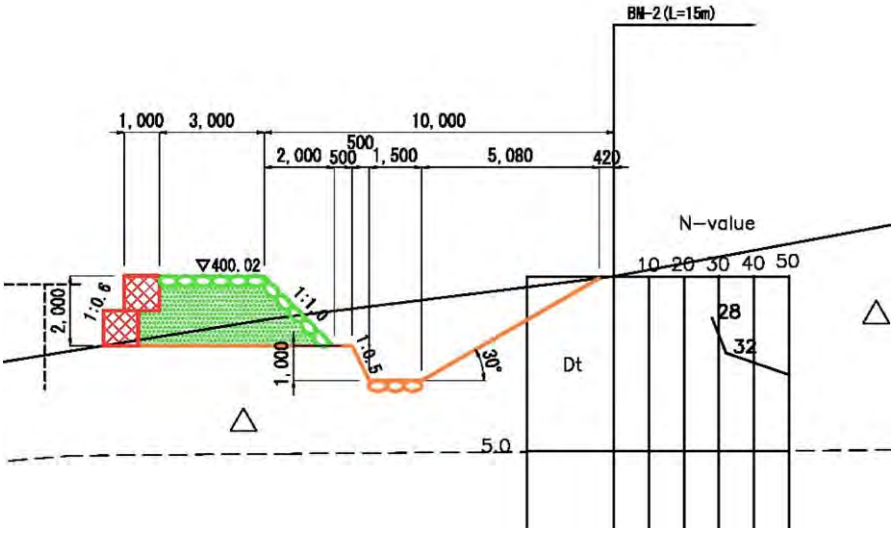


Figure 3.9 Cross section of earth dyke / ditch in the pilot area in Matale

Source: JICA Consultant Team

CHAPTER4 SUPERVISION CONSIDERATION OF TYPICAL COUNTERMEASURES

1. Construction Supervision Standard

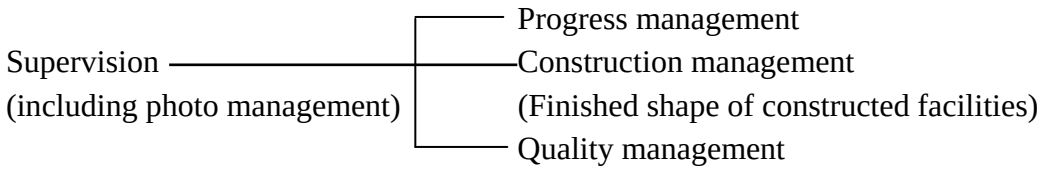
(1) Purpose

The purpose of this construction supervision standard is to keep the period of works, finished shape of constructed facilities and quality management stipulated in the contract document regarding countermeasure works against sediment disasters such as the surface drainage ditch, horizontal drainage drilling and earthwork.

(2) Scope

This standard shall apply to countermeasure works against sediment disasters such as the surface drainage ditch, horizontal drilling and earthwork. However, temporary works without designation in contract documents shall not be included. In addition, if it would be impossible to follow the standard due to types, size and construction conditions of countermeasure works, or countermeasures where the standard and value of the standard are not defined, contractors shall discuss with the Engineer and conduct supervision.

(3) Structure



(4) Management items and methods

a) Progress management

The Contractor shall control the construction schedule adequately according to types of countermeasures. However, regarding construction works impossible to follow the original construction plan such as emergency countermeasures and maintenance, the Contractor shall discuss with the Engineer and conduct progress management adequately. The Contractor shall manage the progress with a daily report, weekly report and monthly progress report and share them with the Engineer and the Employer. A monthly progress meeting should be held each month and the Contractor shall explain the progress of the works and issues and solutions should be discussed with the Engineer and the Employer.

b) Construction management (finished shape of constructed facilities)

The Contractor shall measure the finished shape of constructed facilities in accordance with measurement items and management standard stipulated in the “Construction management standard”. The Contractor shall prepare measurement sheets with a

comparison of the design value and measurement value and submit the measurement sheets with the monthly progress report.

c) Quality management

The Contractor shall manage quality by test items, test methods and test standards in accordance with the quality management standard stipulated in the standards in Sri Lanka and contract documents.

d) Value of standards

The Contractor shall satisfy all of the value of standards in accordance with the construction management standards and the quality management standards.

e) Photo management

The Contractor shall take photos of each construction stage, parts impossible to check after completion of construction, measurements, quality management condition and accidents that occurred during the period of works, etc. in accordance with contract documents and manage them properly. If the Engineer requests submission of the photos, the Contractor shall submit immediately and submit photos with the completion report as well.

f) Safety management

JICA issued "The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects, hereinafter called "The safety guidance" in September 2014. In the pilot projects the safety guidance was applied and the Contractors prepared and submitted "The Safety Management Plan" according to the safety guidance. Safety management is one of the most important issues in construction works, therefore the Contractor shall submit the safety management plan and obtain approval from the Engineer. A daily safety management meeting should be held every morning before commencement of daily works.

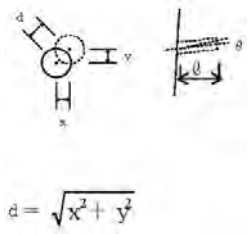
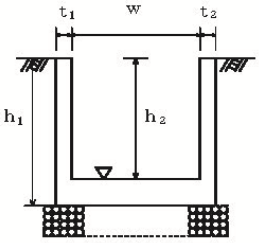
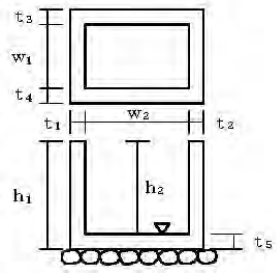
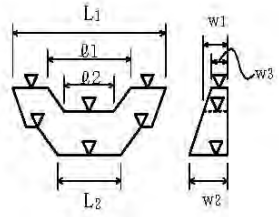
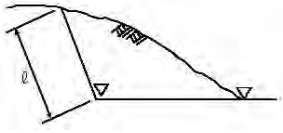
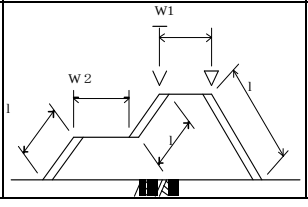
2. Construction Management Standard (finished shape of constructed facilities)

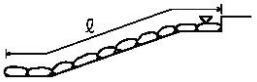
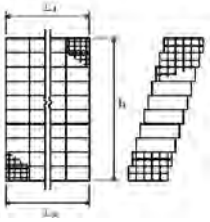
The Contractor shall comply with the construction management standard below. If it would be impossible to follow the standard due to types, size and construction conditions of countermeasure works, or countermeasures where the standards and value of the standards are not defined, contractors shall discuss with the Engineer and conduct supervision. The Contractor shall submit measurement sheets required by the Engineer and submit them with the monthly progress report. A sample of the measurement sheets is attached in Appendix 3.

(Source: Modified from SUPERVISION STANDARD FOR CIVIL WORKS (DRAFT), Published by Ministry of Land, Infrastructure, Transportation and Tourism, March 2016.)

Sri Lanka
National Building Research Organization (NBRO)

Table 4.1 Construction Management Standard (Draft)

Item	Details	Tolerance (Unit: mm)	Inspection Standard	Inspection Point	Method of Management
Horizontal Drainage Drilling	Length of drilling : ℓ	More than design value	All drillings shall be measured. Horizontal angle of drilling shall be measured from the base line.		The list of measured value shall be made.
	Tolerance of placement : d	Less than100mm			
	Angle of drilling : θ	± 2.5°			
Surface Drainage Ditch	Reference height : ▽	±30	One point in every 20m. In case total length is less than 20m, two points in every construction section.		The list of measured value shall be made.
	Thickness : t1, t2	-20			
	Width : w	-20			
	Height :h1, h2	-30			
	Total length : L	-200	Every construction section.		
Water Collecting Pit	Reference height : ▽	±30	Every pit		The list of measured value shall be made.
	Thickness : t1 – t5	-20			
	Width : w1, w2	-20			
	Height : h1, h2	-30			
Small Dam	Reference height : ▽	±30	At the points shown in the figure.		The list of measured value shall be made.
	Width of dam: Top end : w1, w3 Bottom : w2	-30			
	Width of waterway :ℓ 1, ℓ 2	±50			
	Length of dam :L1, L2	-100			
Excavation	Reference height : ▽	±50	One point in every 10m. In case total length is less than 10m, two points in every construction section. Reference height shall be measured at the both ends of the excavation area.		The list of measured value shall be made.
	Length of slope : ℓ — ℓ < 5m	-200			
	Length of slope : ℓ — ℓ ≧ 5m	Length of slope -4%			
Embankment	Reference height :▽	-50	One point in every 10m. In case total length is less than 10m, two points in every construction section. Reference height shall be measured at each top of		The list of measured value shall be made.
	Length of slope :ℓ — ℓ < 5m	-100			
	Length of slope :ℓ — ℓ ≧ 5m	Length of slope -2%			

Item	Details	Tolerance (Unit: mm)	Inspection Standard	Inspection Point	Method of Management
	Width: w1, w2	-100	slope.		
Stone pitching	Reference height : ▽	±100	One point in every 10m. In case total length is less than 10m, two points in every construction section. Design thickness of stone pitching is 400mm. Boulder size is from 400 to 600mm.		The list of measured value shall be made.
	Length of slope : ℓ	-200			
	Total length :L	-200			
	Size of boulder	400-600 ±100			
Gabion	Height : h	-100	One point in every 10m. In case total length is less than 10m, two places in every construction section.		The list of measured value shall be made.
	Total length : L_1, L_2	-200			

Source: Modified from SUPERVISION STANDARD FOR CIVIL WORKS (DRAFT), Published by Ministry of Land, Infrastructure, Transportation and Tourism, March 2016.

3. Earthwork (Cutting Work and Filling Work)

(1) Purpose

Cutting work (excavation) and filling work (embankment) are simple countermeasures against sediment disasters. Especially for landslides, they could be effective and inexpensive countermeasures. On the other hand, an inadequate plan of earthwork could cause other new landslides in landslide prone areas. Therefore adequate plan and management of earthwork should be required for construction work. The purpose of appropriate management of earthwork is to avoid new landslides occurring or sediment disasters in landslide prone areas.

(2) Supervision Consideration

a) Selection of cutting work / excavation method

Cutting work/ excavation method should be selected carefully considering an efficient and economic method in accordance with the schedule of work. If necessary, test excavation should be conducted before the selection of cutting work/ excavation method.

b) Observation during cutting work/ excavation and change of design

During cutting work/ excavation, care should be taken about change of geology. If an unexpected fault fracture zone, dyke and discontinuity layer (joint, bedding, schistosity and fault) are found, cutting work/ excavation should be paused. The actual condition should be compared with the original design, if necessary the design should be changed according to the actual geological condition, at the same time the actual geological condition should be compiled and organized in order to refer to the condition during the maintenance period. Slopes with a retaining wall planned should be steeper than the standard gradient, it could

possibly collapse during or after cutting work/ excavation. In this case, especially during cutting work/ excavation, safety management should be carefully carried out.
If cutting/ excavation depth is much deeper than the groundwater table, sometimes groundwater could become a cause of collapse. The cutting/ excavation level should be divided into several stages and groundwater drainage works should be installed.
Cutting work/ excavation of natural slope sometimes could make stability of the slope decrease, therefore during cutting work/ excavation, observation and monitoring of the slope should be necessary.

c) Protection of slope during cutting work/ excavation

During cutting work/ excavation, erosion by rain, collapse and rock fall could occur. Therefore temporarily drainage work by plastic sheet and sand bags, slope protection by plastic sheets or shotcreting and rock fall prevention work by a steel wire net or fence should be installed.
Especially, if the cutting slope might become unstable, cutting/ excavation should be carried out from the top of the slope and the cutting level should be divided into several stages. In this case, cutting/ excavation should never be carried out from the bottom of the slope (see Fig. 4.1). Also, if the slope might become unstable, cutting/ excavation should never be carried out at the same time. For example, if the length of excavation is 50m, each 5m length should be excavated. The length of excavation each time should depend on the slope condition, therefore the Contractor shall discuss this with the Engineer (see Fig. 4.2).
As mentioned in Chapter3, 2.1, in potential landslide area, if the length of the cutting slope is more than 3m or height of cutting slope is more than 2m, the Contractor shall submit proposal of countermeasure works to the Engineer and approval from the Engineer should be required, even if the cutting is for temporary work such as an access road and cutting for horizontal drainage drilling point, etc.

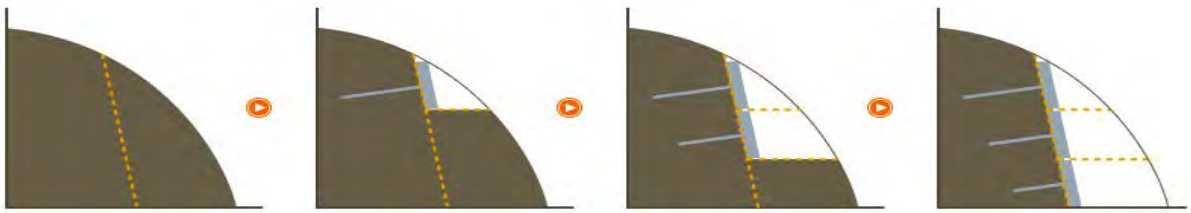


Figure 4.1 Cutting from the top of the slope

Source: http://www.alpha-sgk.co.jp/service.html

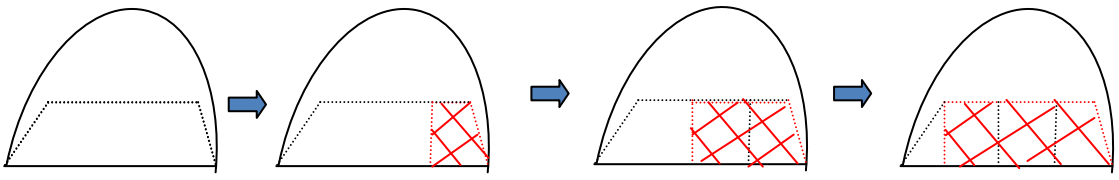


Figure 4.2 Cutting step by step (Source: JICA Consultant Team)

During the construction period of the pilot project, small landslides occurred at drilling points No.1 and 4 due to cutting/ excavation for installation of horizontal drilling platforms in Badulusirigama, Badulla. Finally, reshaping and additional gabion works were conducted for stabilization of the slopes and regarding No.4, even the location of the drilling point was changed.

Cracks at the shoulder of the slope caused by cutting work (Point No.4)

Whole picture of the small landslide (Point No.4)

Small landslide behind the gabion wall caused by cutting work (Point No.1)

Embankment at the middle of the slope (Point No.1)

Photo 4.1 Small landslide caused by cutting work

Source: JICA Consultant Team

d) Filling work/ embankment

The location of filling work/ embankment should be selected carefully and a geological survey should be necessary for foundation of the filling work/ embankment. Compaction should be carried out in accordance with standards in Sri Lanka and contract documents. If filling work/ embankment is installed in a potential landslide area, the location of the filling work/ embankment should be carefully selected in order to avoid causing another new landslide (see Fig. 4.3).

If filling work/ embankment is planned in potential landslide areas, the Contractor shall submit a proposal for countermeasure works and approval

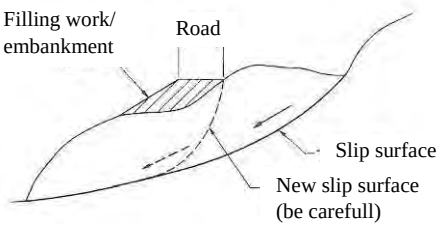


Figure 4.3 Filling work/ embankment in potential landslide area

Source: Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009.

from the Engineer should be required.

4. Surface Drainage Ditch

(1) Purpose

A surface drainage ditch is a quite simple countermeasure but at the same time a quite important measure for sediment disasters because most of the sediment disasters are caused by heavy rain in Sri Lanka. To follow the contract documents such as design and technical specifications of a surface drainage ditch is quite important in order to maintain the function of the surface drainage ditch.

(2) Supervision consideration

a) Concrete grade

The concrete grade of the surface drainage ditch should be more than 25 grade. Otherwise, honeycombs could appear on the surface of the ditch. (see Photo 4.2) The main cause was the concrete grade and insufficient compaction with vibrator might be a cause of the honeycombs. Therefore more than a concrete grade 25 should be used for the surface drainage ditch in order to avoid such honeycombs. Also distribution of reinforce steel bars should follow the original design in order to keep the quality stipulated in the standard in Sri Lanka and the contract document (see Photo 4.3) .

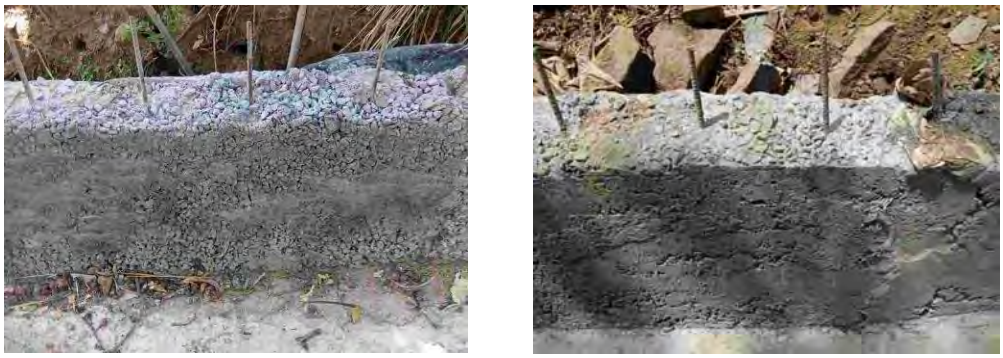


Photo 4.2 Honeycombs of surface drainage ditch (already corrected)

Photo 4.3 Spacing of steel bars do not follow the design (already corrected)

Source: JICA Consultant Team

b) Alignment of surface drainage ditch

If there are too many changes of gradient of slope or sudden change of stream direction,

sometimes it could be difficult to follow the original design. Topographic surveys should be conducted before the construction works along the planned surface drainage ditch line and usually a cross section should be surveyed almost every 20m along the ditch line in the shop drawings. Therefore sometimes it could be difficult to follow the original drawings because the topographic survey cannot cover all of the cross sections along the ditch line. If there are so many changes of gradient of slope or sudden change of direction of stream, the Contractor shall submit a proposal of proper ditch works and an approval from the Engineer should be required. If necessary, additional cross sections should be surveyed depending on the topography along the planned ditch line in the shop drawings. (see Photo 4.4) After the discussion, these sudden curves were corrected in the pilot project. However, some parts have not been corrected completely, and sometimes water overflows at the steep slope and sudden curves. To construct such a steep slope and sudden curve should be avoided in order to avoid overflow at the sudden curve points. (see Photo 4.5) Sometimes land use was a problem to construct ditches as the original design land owners don't allow their land to be used for ditches. In this case, before the construction works, sufficient explanation and discussion should be conducted with land owners to obtain the land owner's agreement.

Photo 4.4 Sudden curves of ditch (already corrected)

Photo 4.5 Sudden curves of ditch

Source: JICA Consultant Team

c) Design of surface drainage ditch

As mentioned in Chapter 3, 2.3, the water flow rate should be calculated and adequate size

of the surface drainage ditch should be selected. The water flow rate should be changed at confluences of ditches, therefore the size of the ditches should be changed before and after the confluences of ditches. At the same time, a water collecting pit (catch pit) should be installed at the confluences of ditches. The main functions of the water collecting pit are connection of ditches, deposit of soil, preventing hydraulic jump and a function of the drop structure. Catch pits should be installed at the confluences of ditches, curving parts of ditches and slope change points.

d) Change in topography

This is almost the same issue as cutting and filling work. In principle, a drastic change of topography is not preferable inside potential landslide areas considering stability of potential landslide, landscape and so on. In the pilot projects, fortunately no landslides occurred caused by cutting and filling for surface drainage ditches. However, as mentioned in Chapter 3, 2.3, if the length of the cutting slope is more than 3m or the height of the cutting slope is more than 2m, the Contractor shall submit a proposal of countermeasure works to the Engineer and approval from the Engineer should be required. Moreover, too much cutting and filling has caused erosion and sedimentation in the pilot project site. Especially, in the lower slope of the site, some ditches and pits have been filled by soil due to random cuttings. If these kinds of large cuttings should be necessary, an approval by the Engineer should be required.

Photo 4.6 Pond before the construction (left) During the construction (right)

Photo 4.6 After the construction Pits are filled by soils

Source: JICA Consultant Team

5. Horizontal Drainage Drilling

(1) Purpose

Horizontal drainage drilling is also quite an important countermeasure work for landslide/ sediment disaster because the main cause of the landslide is heavy rainfall in Sri Lanka, and due to heavy rain, the groundwater level becomes higher and the landslide becomes unstable. The purpose of the horizontal drainage drilling is to collect the groundwater and drain the groundwater outside of the landslide potential area.

(2) Supervision consideration

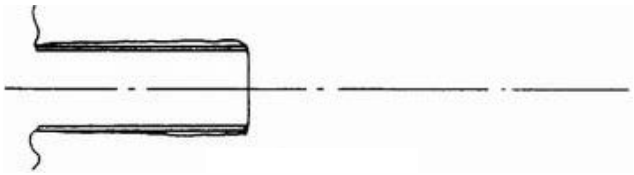
a) Casing pipes

To use casing pipes is quite important when horizontal drainage drilling is conducted in potential landslide areas. Usually in potential landslide areas, the geology mainly consists of debris generated by movement of the landslide. Therefore the geology should be a mixture of soft soil and hard or soft rocks. It is difficult to conduct horizontal drilling in debris generated by landslide movement because the geology is too soft and quite easy to collapse inside the drilling hole. After the completion of drilling, PVC pipes should be installed in the drilling hole. When PVC pipes are installed in the drilling hole, the drilling hole should be reinforced, therefore casings should be used to keep the drilling hole stable during the drilling and after the drilling in order to install PVC pipes in the drilling hole.

A typical example of horizontal drainage drilling is shown below.

i) Drilling

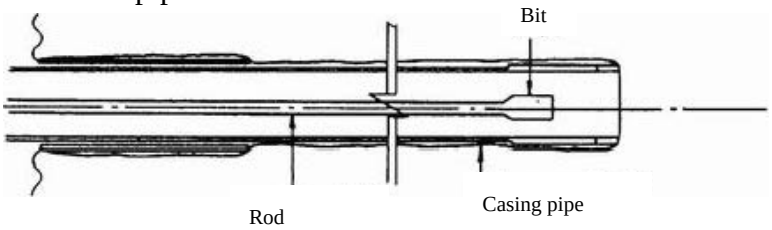
After drilling 5-7m from the opening of the hole, the hole opening pipe should be inserted in order to keep the opening of the hole.



Drilling at the opening of the hole

ii) Drilling and cleaning

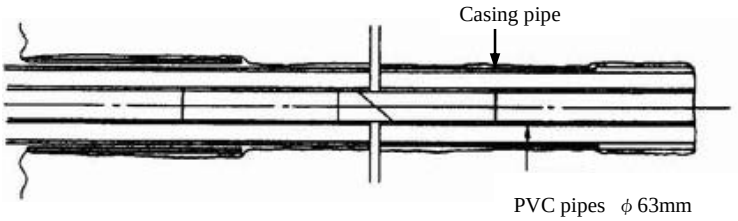
Drill inside the opening pipe and install casing pipes. If soil is inside the casing pipes, wash and clean inside the pipes.



Drilling and cleaning

iii) Installation of PVC pipes into the drilling hole

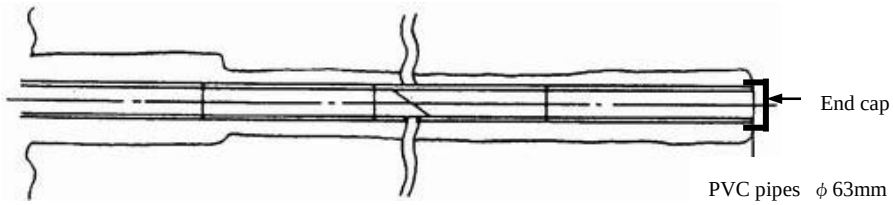
After the completion of the drilling, install PVC pipes into the drilling hole. If the diameter of the drilling is 100mm, do not use PVC pipes with a 90mm diameter. It should be difficult to install 90 mm diameter PVC pipes because the difference of diameter between the drilling hole and PVC pipes is quite small. It is better to use 63mm diameter PVC pipes.



Installation of PVC pipes

iv) Completion

After the installation of the PVC pipes, remove the casing pipes. An end cap should be installed to avoid soil flowing into the PVC pipes.



Completion of horizontal drainage drilling

Source: http://www.jasdim.or.jp/gijutsu/jisuberi_joho/taisaku/yokob/model.html

b) Geotextile wrapped on PVC pipes

Wrapping of the geotextile in the PVC pipe is important. Sometimes the geotextile becomes unstuck because of improper wrapping. After that soil flows into the PVC pipes, and the PVC pipes might be blocked. Actually, after the change of wrapping from left to right (see Photo 4.7), PVC pipes were not blocked in the pilot project.

Photo 4.7 Wrapping of geotextile to PVC pipes
(left: improper wrapping, right: proper wrapping)

Source: JICA Consultant Team

c) Drilling machine

Selection of the drilling machine is quite important because the drilling machine is bigger, sometimes the volume of the slope cutting becomes bigger to set the drilling machine at the drilling location. It is very important to avoid cutting too much to set the drilling machine in order to keep stability of the slope. Already mentioned in Chapter 3, 3.3, a huge volume of cuttings and fillings in potential landslide areas makes the slope unstable. Therefore it is recommendable to use a drilling machine to drill horizontal holes as small as possible. Of course the selection of the drilling machine depends on specifications such as length, diameter of drilling, geological conditions and so on. The Contractor shall submit a construction plan including temporary works of setting the drilling machine and a temporary access road to mobilize the machine, and obtain approval from the Engineer before the construction works. Examples of drilling machines are shown below. Crawler type drilling machines require a temporary access road and a bigger space for setting the machine. Therefore the crawler type is not recommended at steep slopes or inside landslide potential areas.

Photo 4.8 Rotary drilling machines: Small type drilling machine (left), horizontal drilling machine (right)

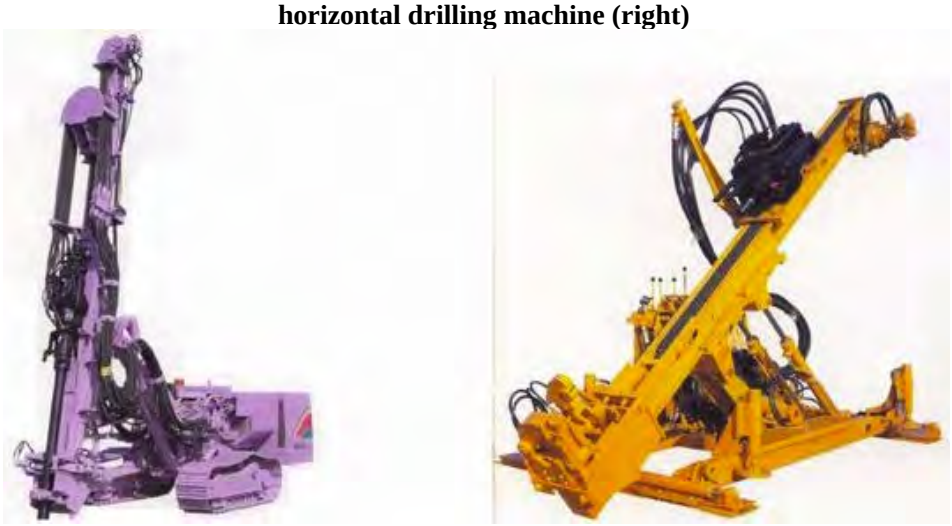


Photo 4.9 Rotary percussion drilling machines: Crawler type (left), skid type (right)

Source: http://www.jasdim.or.jp/gijutsu/jisuberi_joho/taisaku/yokob/model.html

During the project, cracks appeared at a house around the drilling site in Udamadura, Nuwara Eliya. The relationship was not clear between the drilling works and the cracks because the distance between the end of the drilling hole and the house was around 20m and the difference of elevation was around 15m. In Japan, we have no similar phenomena therefore it was an unbelievable phenomenon because the distance and the elevation were too large to be. If the distance was much closer, it might happen. The cause was supposed that the vibration of the rotary percussion drilling machine might affect the appearance of the cracks. Therefore, after the appearance of the cracks, the drilling machine was changed from a rotary percussion type to a rotary type. Finally, after the change of the drilling machine, no more cracks appeared and the existing cracks weren't extended.

Although the cause of the appearance of the cracks was not clear, at least a rotary percussion type drilling machine could affect the appearance of the cracks. Thus if similar phenomena occur, the solution might be to change the type of drilling machine.

Photo 4.10 Cracks appeared on the wall of the house

CHAPTER5 MONITORING/ MAINTENANCE

1. General

Countermeasure works against landslide/ sediment disaster are planned considering the size of collapse or landslides, mechanism and objects to be preserved from disasters and so on. The countermeasures should be planned as a factor of safety for a long period. Countermeasure works installed at steep slopes or landslide areas are often exposed to severe conditions. Therefore deterioration of materials and damages are often observed and functions expected are sometimes lost or decreased. Once countermeasure works have been completed, countermeasure works have been deemed as completed facilities. However, countermeasure works should be monitored and their functions kept for slope stability.

Monitoring/ maintenance are classified into four (4) categories shown in Table 5.1

Table 5.1 Type of monitoring/ maintenance

Type of monitoring/ maintenance	Purpose	Contents	Frequency
Initial monitoring	Just after the completion of facilities, initial condition should be recorded.	✓ Compare with monitoring results as a basis.	One time
Routine monitoring/ maintenance	Check the actual condition of facilities in the routine monitoring/ maintenance.	✓ Check actual condition of the facilities. ✓ It is difficult to judge the deterioration of function of facilities except obvious damages.	two (2) – six (6) times in a year approximately
Periodic monitoring/ maintenance	Check the actual condition of facilities periodically.	✓ Compare with initial monitoring or previous periodic monitoring results.	Once in three (3) – five (5) years approximately.
Urgent monitoring/ maintenance	After heavy rain, check the actual condition of the facilities.	✓ When unexpected external force might cause damages to the facilities, mainly damages of facilities should be checked.	Timely basis.

Source: OPERATION GUIDE FOR MAINTENANCE OF SLOPE DISASTER MITIGATION WORKS, Published by Japan Association for Slope Disaster Management, December 2016

2. Surface Drainage Ditch

Deterioration in functioning of the surface drainage ditch is caused by alteration or corrosion of materials by aging such as sunshine, rainfall and so on, deformation by gaps in the joints, deformation or damage by landslide movement and earth pressure or blockage by collapse or soil flowing into the ditch or plants, and erosion along the ditch by overflow or leaking.

Especially ditches installed at scarp or cracks of landslides tend to generate gaps in the

joints, it should be important to check areas that tend to cause phenomena such as landslide movements.
Examples of deterioration of a surface drainage ditch are shown in Fig. 5.1.

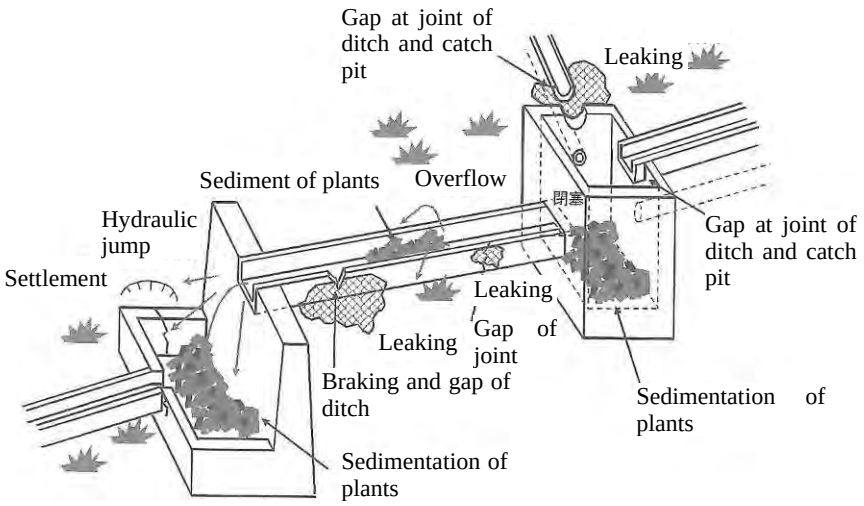


Figure 5.1 Damages along surface drainage ditch

Source: OPERATION GUIDE FOR MAINTENANCE OF SLOPE DISASTER MITIGATION WORKS, Published by Japan Association for Slope Disaster Management, December 2016

3. Horizontal Drainage Drilling

Blockage by bacteria, algae and soils included in groundwater and penetration by roots of plants tend to occur. Deterioration of PVC pipes by water quality and damage such as cracks and gaps are sometimes found. Examples of deterioration of horizontal drainage are shown in Fig. 5.2.

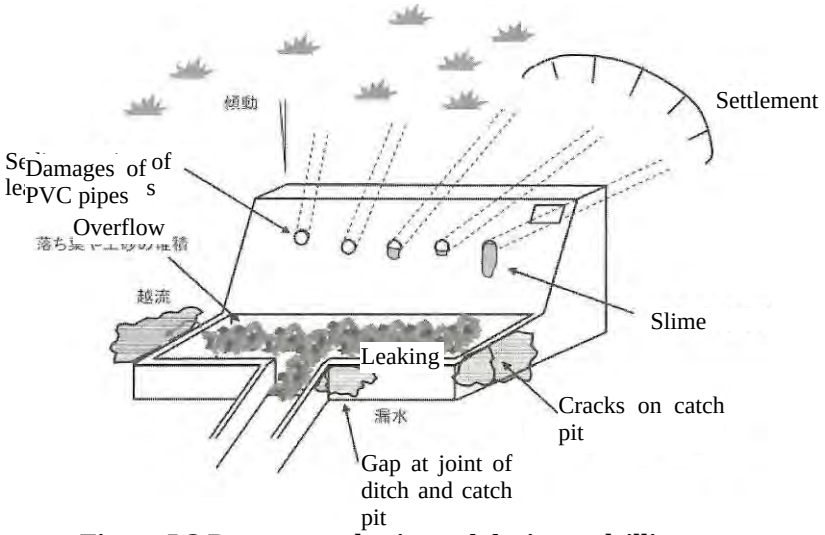


Figure 5.2 Damages at horizontal drainage drilling

Source: OPERATION GUIDE FOR MAINTENANCE OF SLOPE DISASTER MITIGATION WORKS, Published by Japan Association for Slope Disaster Management, December 2016

When monitoring is conducted, the water flow rate should be measured in order to check the function of horizontal drainage drilling. Figure 5.3 shows the water flow rate in 2016 and 2017 in Nuwara Eliya. The water flow rate should be compared with the data, and if the water flow rate is less than the data considering rain fall data, washing and cleaning of drainage holes might be conducted. Attention should be paid that the data of the water flow rate was only once a month, but the rain fall data was cumulative data of daily rain fall. Therefore the water flow data could be a reference.

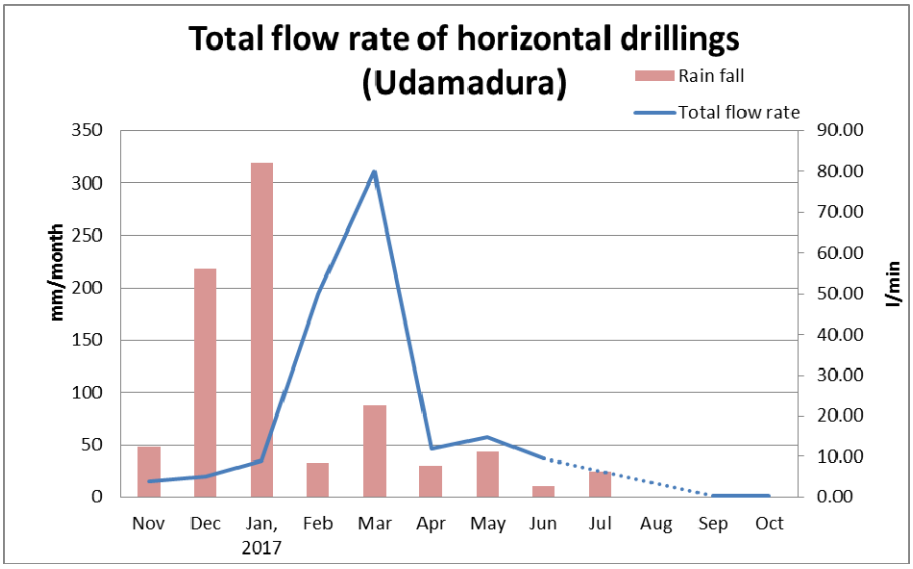


Figure 5.3 Water flow rate of horizontal drillings in Nuwara Eliya

Source: JICA Consultant Team

4. Earth Dyke

Deterioration of steel wire of the gabion, deformation of embankment and blockage of the catch pocket should be checked for the earth dyke countermeasures against rock fall. Examples of deterioration or damage of the earth dyke are shown in Fig. 5.4. Monitoring sheets of

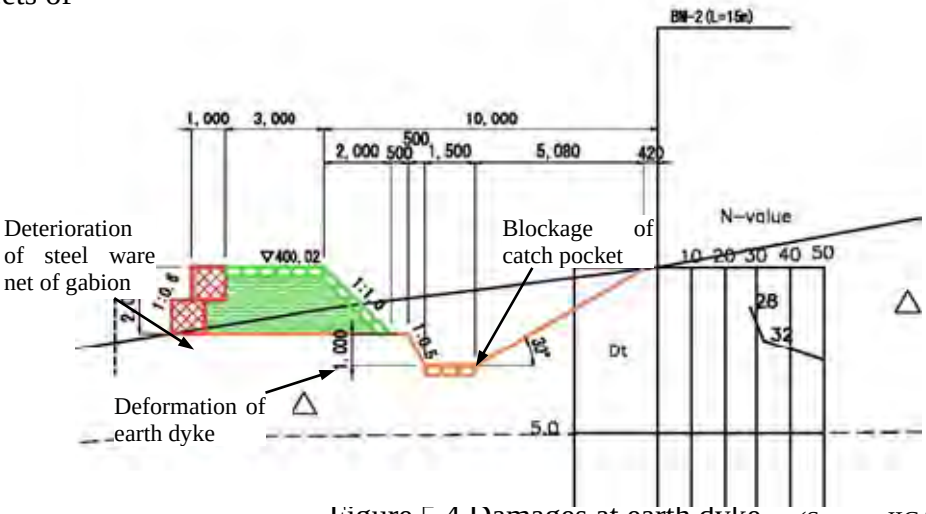


Figure 5.4 Damages at earth dyke (Source: JICA Consultant Team)

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APPENDIX

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Appendix 1

References

No.1 DESIGN GUIDE －EARTHWORKS, Published by Japan Highway Public Corporation, May 1998.

No.2 Highway Earthwork Series, MANUAL FOR SLOPE PROTECTION, Published by Japan Road Association, June 2009.

No.3 MANUAL FOR COUNTERMEASURE WORKS AGAINST SLOPE FAILURE, Japan Sabo Association, July 1996

No.4 MANUAL FOR COUNTERMEASURES AGINST ROCK FALL, Published by Japan Road Association, June 2000.

No.5 Highway Earthwork Series, MANUAL FOR DRAINAGE WORKS, Published by Japan Road Association, June 1987

No.6 SUPERVISION STANDARD FOR CIVIL WORKS (DRAFT), Published by Ministry of Land, Infrastructure, Transportation and Tourism, March 2016.

No.7 OPERATION GUIDE FOR MAINTENANCE OF SLOPE DISASTER MITIGATION WORKS, Published by Japan Association for Slope Disaster Management, December 2016

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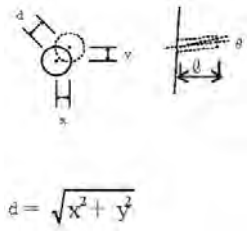
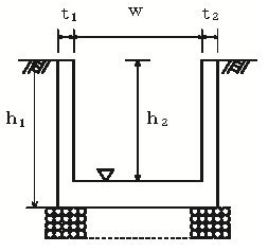
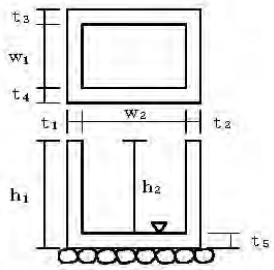
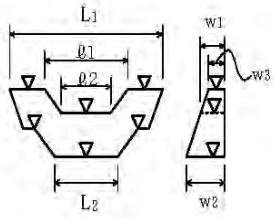
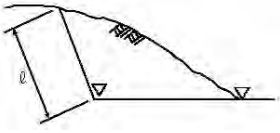
Appendix 2

Construction Management Standard (Draft)

Item	Details	Tolerance (Unit: mm)	Inspection Standard	Inspection Point	Method of Management
Horizontal Drainage Drilling	Length of drilling : ℓ	More than design value	All drillings shall be measured. Horizontal angle of drilling shall be measured from the base line.		The list of measured value shall be made.
	Tolerance of placement : d	Less than100mm			
	Angle of drilling : θ	± 2.5°			
Surface Drainage Ditch	Reference height : ▽	±30	One point in every 20m. In case total length is less than 20m, two points in every construction section.		The list of measured value shall be made.
	Thickness : t1, t2	-20			
	Width : w	-20			
	Height :h1, h2	-30			
	Total length : L	-200	Every construction section.		
Water Collecting Pit	Reference height : ▽	±30	Every pit		The list of measured value shall be made.
	Thickness : t1 – t5	-20			
	Width : w1, w2	-20			
	Height : h1, h2	-30			
Small Dam	Reference height : ▽	±30	At the points shown in the figure.		The list of measured value shall be made.
	Width of dam: Top end : w1, w3 Bottom : w2	-30			
	Width of waterway :ℓ 1, ℓ 2	±50			
	Length of dam :L1, L2	-100			
Excavation	Reference height : ▽	±50	One point in every 10m. In case total length is less than 10m, two points in every construction section. Reference height shall be measured at the both ends of the excavation area.		The list of measured value shall be made.
	Length of slope : ℓ — ℓ < 5m	-200			
	Length of slope : ℓ — ℓ ≧ 5m	Length of slope -4%			

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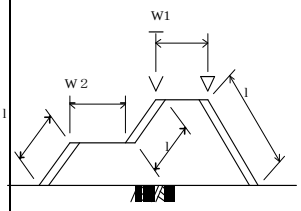
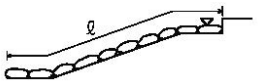
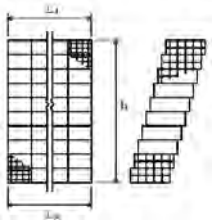
Item	Details		Tolerance (Unit: mm)	Inspection Standard	Inspection Point	Method of Management
Embankment	Reference height :▽		-50	One point in every 10m. In case total length is less than 10m, two points in every construction section. Reference height shall be measured at each top of slope.		The list of measured value shall be made.
	Length of slope :ℓ	ℓ ＜ 5m	-100			
		ℓ ≧ 5m	Length of slope -2%			
	Width: w1, w2		-100			
Stone pitching	Reference height : ▽		±100	One point in every 10m. In case total length is less than 10m, two points in every construction section. Design thickness of stone pitching is 400mm. Boulder size is from 400 to 600mm.		The list of measured value shall be made.
	Length of slope : ℓ		-200			
	Total length :L		-200			
	Size of boulder		400-600 ±100			
Gabion	Height : h		-100	One point in every 10m. In case total length is less than 10m, two places in every construction section.		The list of measured value shall be made.
	Total length : L_1, L_2		-200			

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Appendix 3

Sample of Measurement Sheet (Draft)

Horizontal Drainage Drilling No.1

Date :

Time:

Length

	Item	Design Length (mm)	Tolerance (mm)	Measured Length (mm)	Check (The Engineer)	Check (The Contractor)	Designed Placement (mm)	Measured Placement (mm)	Tolerance (mm)	Check (The Engineer)	Check (The Contractor)	Design Angle (degree)	Tolerance (degree)	Measured Angle (degree)	Check (The Engineer)	Check (The Contractor)
1	1	45,000	More than Design Length						±100			5	±2.5			
2	2	45,000										5				
3	3	45,000										5				
4	4	45,000										5				
5	5	45,000										5				
6	6	45,000										5				
7	7	45,000										5				
8	8	45,000										5				
9																
10																
	Total	360,000														

Surface Drainage Ditch

Width : w Type A

	Inspection Point	Design width (mm)	Tolerance (mm)	Measured width (mm)	Check (The Engineer)	Check (The Contractor)
1	A	1,438	-20			
2	B	1,438				
3	C	1,438				
4	D	1,438				
5	E	1,438				
6	F	1,438				
7	G	1,438				
8	H	1,438				
9	I	1,438				
10	J	1,438				

Date :

Time :

Width : w Type B

	Inspection Point	Design width (mm)	Tolerance (mm)	Measured width (mm)	Check (The Engineer)	Check (The Contractor)
1	A	1,158	-20			
2	B	1,158				
3	C	1,158				
4	D	1,158				
5	E	1,158				
6	F	1,158				
7	G	1,158				
8	H	1,158				
9	I	1,158				
10	J	1,158				

Water Collecting Pit

Mix propotion of concrete

Date:

Time:

	Inspection Point	Reference height (mm)	Tolerance (mm)	Measured weight of cement(mm)	Check (The Engineer)	Check (The Contractor)	Measured weight of sand (mm)	Check (The Engineer)	Check (The Contractor)	Measured weight of aggregate(mm)	Check (The Engineer)	Check (The Contractor)
1	A											
2	B											
3	C											
4	D											
5	E		±30									
6	F											
7	G											
8	H											
9	I											
10	J											

Water Collecting Pit

Reference height

	Pit	Reference height (mm)	Tolerance (mm)	Measured height (mm)	Check (The Engineer)	Check (The Contractor)
1	A					
2	B					
3	C					
4	D					
5	E		±30			
6	F					
7	G					
8	H					
9	I					
10	J					

Excavation							Date :			Time :			
Reference height							Slope length A						
	Inspection Point	Reference height (mm)	Tolerance (mm)	Measured height (mm)	Check (The Engineer)	Check (The Contractor)		Inspection Point	Design slope length (mm)	Tolerance (mm)	Measured slope length (mm)	Check (The Engineer)	Check (The Contractor)
1	A		±50				1	A	5,863.5	Slope length −4%			
2	B						2	B					
3	C						3	C					
4	D						4	D					
5	E						5	E					
6	F						6	F					
7	G						7	G					
8	H						8	H					
9	I						9	I					
10	J						10	J					
										−200			

Embankment Height: 1,600mm

Reference height

	Inspection Point	Reference height (mm)	Tolerance (mm)	Measured height (mm)	Check (The Engineer)	Check (The Contractor)
1	A		-50			
2	B					
3	C					
4	D					
5	E					
6	F					
7	G					
8	H					
9	I					
10	J					

Date :

Time :

Slope length

	Inspection Point	Design slope length (mm)	Tolerance (mm)	Measured slope length (mm)	Check (The Engineer)	Check (The Contractor)
1	A	2,824	-100			
2	B					
3	C					
4	D					
5	E					
6	F					
7	G					
8	H					
9	I					
10	J					

Slope length -2%

Stone Pticking Thickness: 400mm Size of boulder : 400mm to 600mm

Date :

Time :

Reference height

	Inspection Point	Reference height (mm)	Tolerance (mm)	Measured height (mm)	Check (The Engineer)	Check (The Contractor)
1	A		±100			
2	B					
3	C					
4	D					
5	E					
6	F					
7	G					
8	H					
9	I					
10	J					

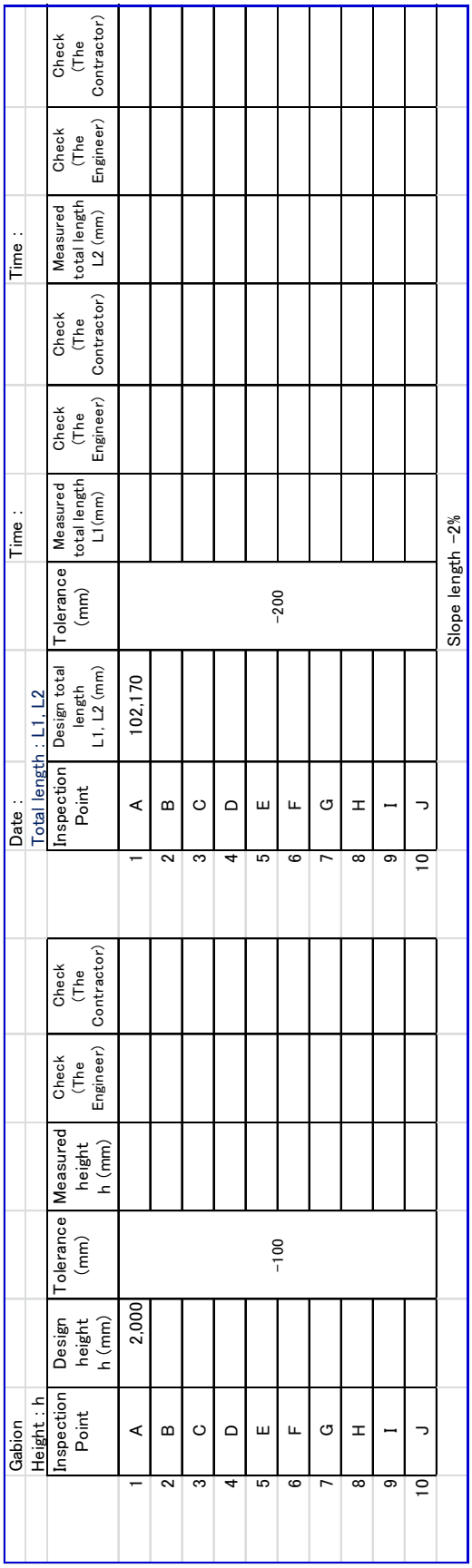
Slope length : l

	Inspection Point	Design slope length (mm)	Tolerance (mm)	Measured slope length (mm)	Check (The Engineer)	Check (The Contractor)
1	A		-200			
2	B					
3	C					
4	D					
5	E					
6	F					
7	G					
8	H					
9	I					
10	J					

Slope length −2%

Total length : L

	Inspection Point	Design total length L (mm)	Tolerance (mm)	Measured total length L (mm)	Check (The Engineer)	Check (The Contractor)
1	A		-200			
2	B					
3	C					
4	D					
5	E					
6	F					
7	G					
8	H					
9	I					
10	J					



Gabion
Height : h

	Inspection Point	Design height h (mm)	Tolerance (mm)	Measured height h (mm)	Check (The Engineer)	Check (The Contractor)
1	A	2,000	-100			
2	B					
3	C					
4	D					
5	E					
6	F					
7	G					
8	H					
9	I					
10	J					

Date :
Time :
Total length : L1, L2

	Inspection Point	Design total length L1, L2 (mm)	Tolerance (mm)	Measured total length L1(mm)	Check (The Engineer)	Check (The Contractor)	Measured total length L2 (mm)	Check (The Engineer)	Check (The Contractor)
1	A	102,170	-200						
2	B								
3	C								
4	D								
5	E								
6	F								
7	G								
8	H								
9	I								
10	J								

Slope length −2%

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Appendix 4

Monitoring Sheet (Draft)

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Monitoring Sheet
Badulusirigama

Date:

Affiliation: Name:

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location:	(shown in the map)

Facility	Location No	Outline of monitoring result Evidence of damage level	Damage level	Comment, countermeasure, etc.
Surface drainage ditch	1			
	2			
	3			
	4			
Water collecting pit	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
Horizontal drilling	1			
	2			
	3			
	4			
	5			
	6			
Ground condition around ditch	1			
	2			
	3			

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

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Evaluation standard for damage level of facilities

Damage level		Description
Damage Deformation /Alteration Corrosion /Blockage	a (IV)	There are no damage/ alteration/ blockage and so on (hereinafter referred to as damage) of facility itself. Or there are slight damages observed, however there are no decreases of functional status by the damage. Therefore no countermeasure is required.
	b (III)	There are some damages such as cracks or rusting observed however there are no decreases of functional status by the damage. At the moment there are no necessity for countermeasures, however continuous monitoring is required by periodic inspection in order to clarify causes of damages or to observe expansion of the cracks.
	c (I, II)	There are extremely damages of facility itself. There are obvious decreases of functional status by the damage, or stability of member and decreases of strength are concerned.

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Surface Drainage Ditch

Date:

Affiliation: Name:

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location:	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No.	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Horizontal Drainage Drilling

Date:

Affiliation: Name:

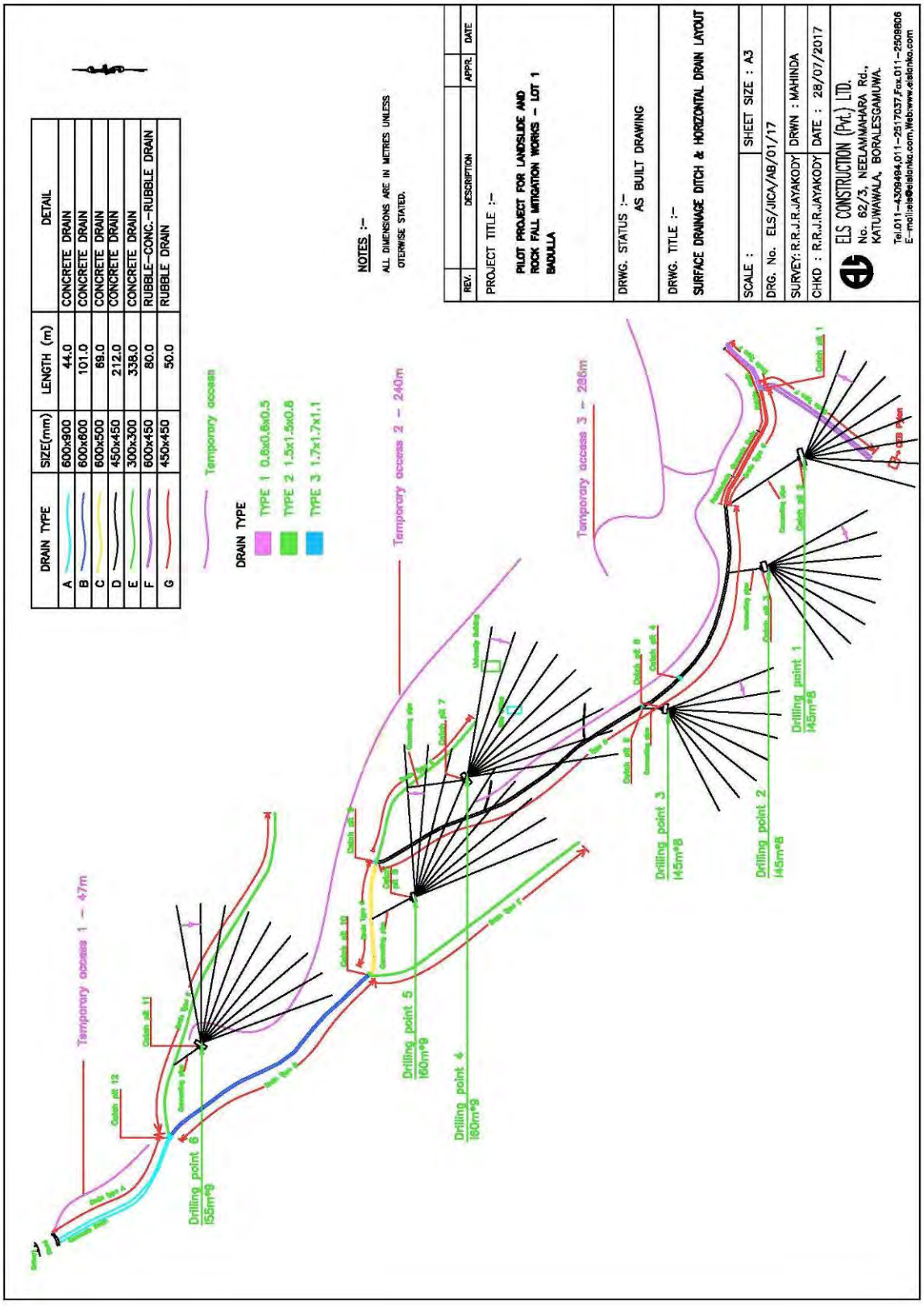
Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location: Drilling Point	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No.	Damage level
PVC pipe	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Connecting pipe	Blockage	1. Blockage 2. Clogging				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Drainage pipe connecting to ditch	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Ground condition around drilling point	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Sri Lanka
National Building Research Organization (NBRO)



Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Photo

Date:

Affiliation: TCLMP Name: o

Date:

Affiliation: Name:

Site: Uva Province	Badulla District	Badulusirigama
Completed year: 2017	Location:	(shown in the map)

Photo 1:	Photo 2:
Photo 3: h	Photo 4:
Photo 5:	Photo 6:

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Udamadura

Date:

Affiliation: Name:

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location:	(shown in the map)

Facility	Location No	Outline of monitoring result Evidence of damage level	Damage level	Comment, countermeasure, etc.
Surface drainage ditch	1			
	2			
	3			
	4			
Water collecting pit	1			
	2			
	3			
	4			
	5			
Horizontal drilling	1			
Ground condition around ditch	1			
	2			
	3			

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Evaluation standard for damage level of facilities

Damage level		Description
Damage Deformation /Alteration Corrosion /Blockage	a (IV)	There are no damage/ alteration/ blockage and so on (hereinafter referred to as damage) of facility itself. Or there are slight damages observed, however there are no decreases of functional status by the damage. Therefore no countermeasure is required.
	b (III)	There are some damages such as cracks or rusting observed however there are no decreases of functional status by the damage. At the moment there are no necessity for countermeasures, however continuous monitoring is required by periodic inspection in order to clarify causes of damages or to observe expansion of the cracks.
	c (I, II)	There are extremely damages of facility itself. There are obvious decreases of functional status by the damage, or stability of member and decreases of strength are concerned.

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Surface Drainage Ditch

Date:

Affiliation: Name:

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location:	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No.	Damage level
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage 9. Overflow/ ponding				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Side of ditch	Damage Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
	Alteration Corrosion	1. Surface deterioration 2. Crack				
Base concrete	Deformation	1. Gap 2. Uneven settlement				
	Sediment outflow	1. Scouring 2. Subsidence				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Ground condition around ditch	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Horizontal Drainage Drilling

Date:

Affiliation: Name:

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location: Drilling Point	(shown in the map)

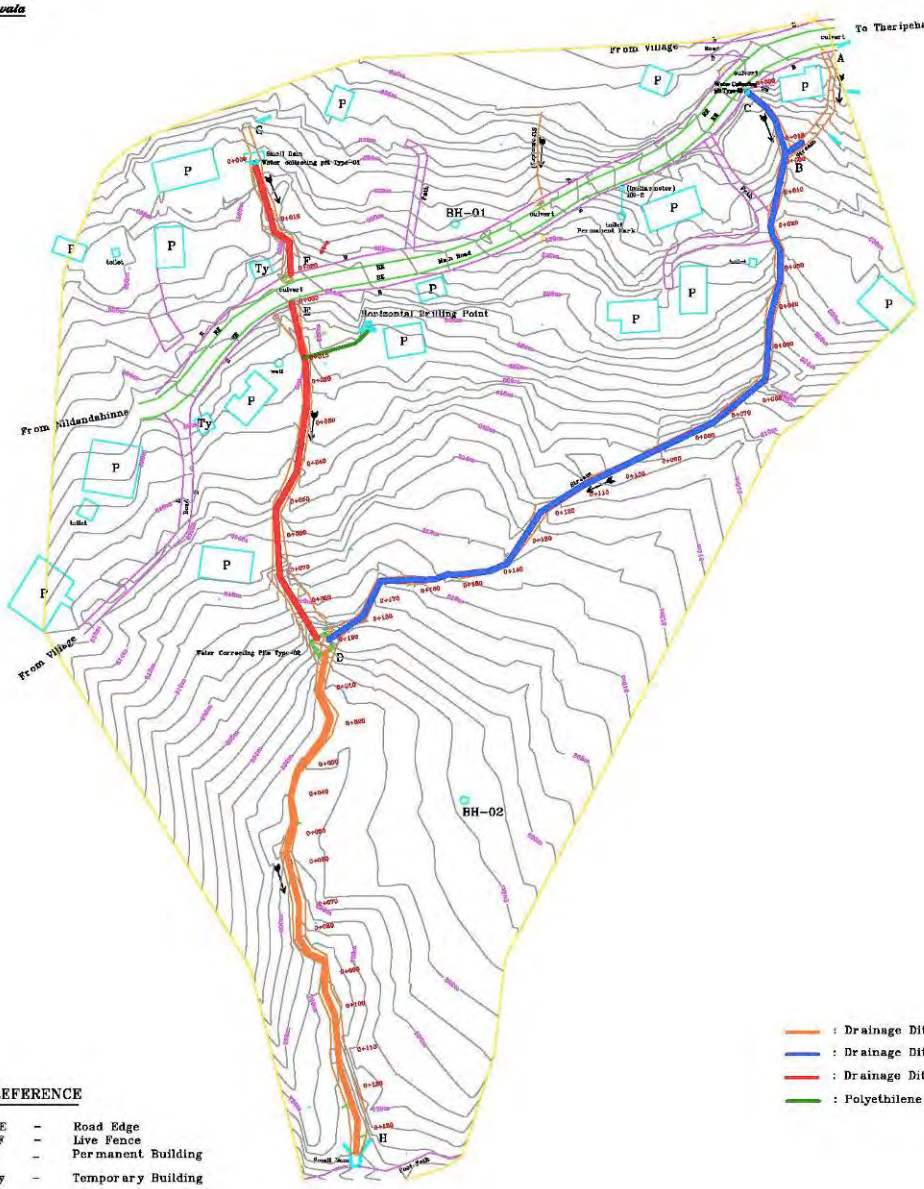
Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No.	Damage level
PVC pipe	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Connecting pipe	Blockage	1. Blockage 2. Clogging				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Water collecting pit	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8. Leakage				
	Alteration Corrosion	1. Surface deterioration 2. Free lime 3. Chipping 4. Rust leachate 5. Rusting 6. Perforation 7. Change color				
	Blockage	1. Overflow 2. Ponding 3. Sediment				
Drainage pipe connecting to ditch	Blockage	1. Blockage 2. Clogging 3. No water				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Bending				
	Alteration Corrosion	1. Surface deterioration 2. Rusting 3. Perforation 4. Change color				
Ground condition around drilling point	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

THE PILOT PROJECT FOR LANDSLIDE AND ROCK FALL MITIGATION WORKS
UDAMADURA, NUWARAELIYA
Finalized Survey Plan of the Area

C.E.N.Thilakaratri
Licensed Surveyor & Leveller.
No.172/1
Bandarawatta
Nandawala



REFERENCE

RE	–	Road Edge
LF	–	Live Fence
P	–	Permanent Building
Ty	–	Temporary Building
B	–	Bank
BH	–	Bore Hall

: Drainage Ditch TYPE-A (134.2 m)
: Drainage Ditch TYPE-B (217.4 m)
: Drainage Ditch TYPE-C (114.1 m)
: Polyethilene HDPE Pipe

Employer :
Japan International Cooperation Agency

Engineer :
National Building Research Organization

Contractor :
Geo Engineering Consultants Pvt Ltd

Surveyed on _____
Certified By:

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet

Photo

Date: _____

Affiliation: _____ Name: _____

Site: Central Province	Nuwara Eliya District	Udamadura
Completed year: 2017	Location:	(shown in the map)

Photo 1:	Photo 2:
Photo 3:	Photo 4:
Photo 5:	Photo 6:

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Alagumale

Date:

Affiliation: Name:

Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location:	(shown in the map)

Facility	Location No	Outline of monitoring result Evidence of damage level	Damage level	Comment, countermeasure, etc.
Gabion wall	1			
	2			
	3			
	4			
Earth dyke	1			
	2			
	3			
Catch pocket	1			
	2			
	3			
Surface drainage ditch	1			
	2			
	3			
Ground condition around ditch	1			
	2			
	3			

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Sri Lanka
National Building Research Organization (NBRO)

Evaluation standard for damage level of facilities

Damage level		Description
Damage Deformation /Alteration Corrosion /Blockage	a (IV)	There are no damage/ alteration/ blockage and so on (hereinafter referred to as damage) of facility itself. Or there are slight damages observed, however there are no decreases of functional status by the damage. Therefore no countermeasure is required.
	b (III)	There are some damages such as cracks or rusting observed however there are no decreases of functional status by the damage. At the moment there are no necessity for countermeasures, however continuous monitoring is required by periodic inspection in order to clarify causes of damages or to observe expansion of the cracks.
	c (I, II)	There are extremely damages of facility itself. There are obvious decreases of functional status by the damage, or stability of member and decreases of strength are concerned.

Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet
Earth Dyke

Date:

Affiliation: Name:

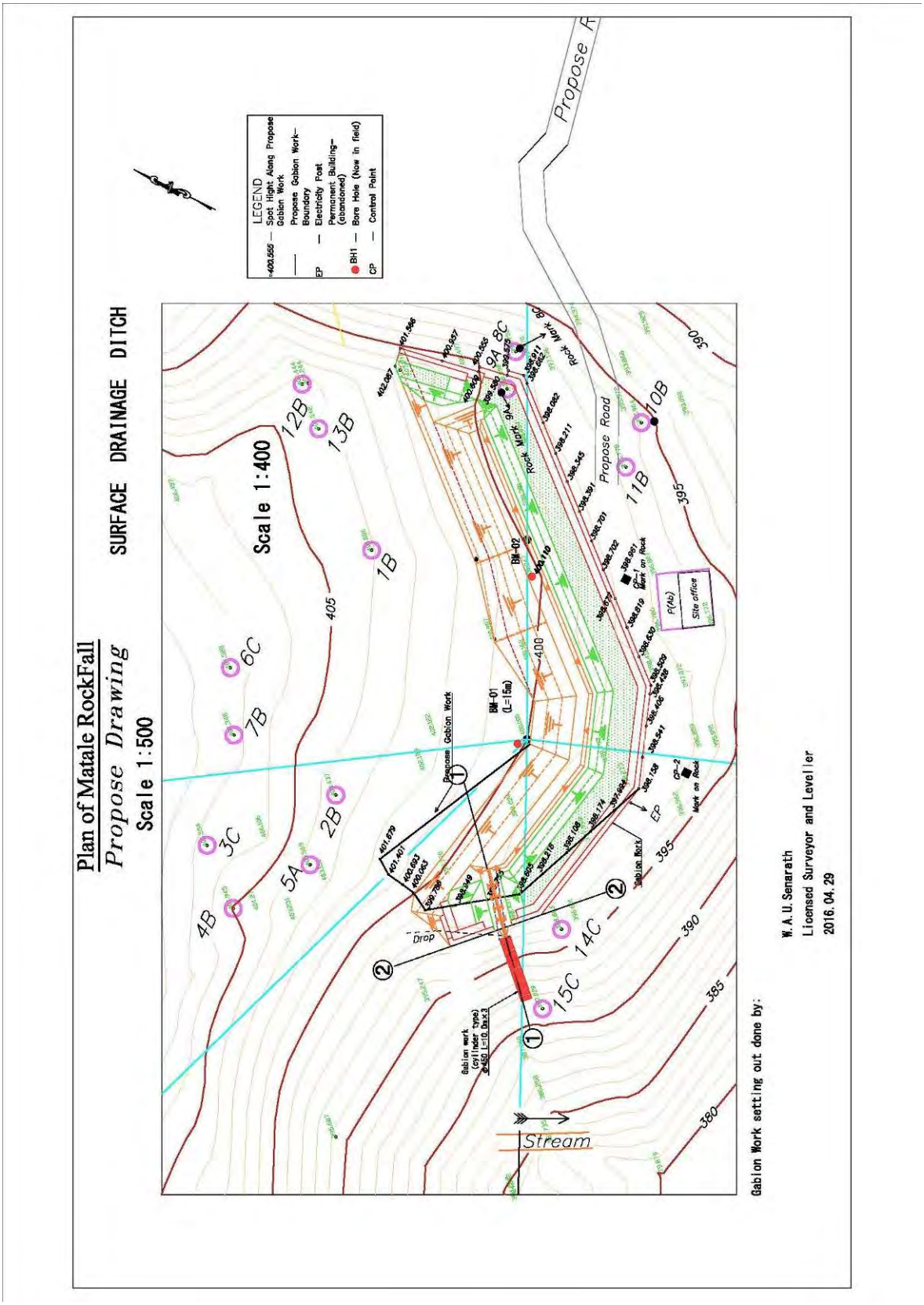
Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location:	(shown in the map)

Facility	Phenomena (Check item)		No.	Outline of monitoring result Evidence of damage level	Photo No.	Damage level
Gabion wall	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring				
	Alteration Corrosion	1. Rusting 2. Change color				
Earth dyke	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Uneven settlement 5. Inclination 6. Jutting 7. Scouring 8. Erosion of surface 9. Removal of pitch stone				
Catch pocket	Blockage	1. Blockage by rock fall 2. Blockage by sediment				
	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Jutting 5. Souring 6. Erosion				
Surface drainage ditch	Damage Deformation	1. Crack 2. Fracture 3. Gap 4. Wear/abrasion, 5. Bending 6. Inclination 7. Change of gradient 8.Scouring 9. Erosion 10. Removal of pitch stone				
	Blockage	1. Blockage by Rock fall 2. Blockage by Sediment				
Ground condition around dyke	Damage Deformation	1. Scouring 2. Collapse 3. Crack 4. Subsidence 5. Upheaval 6. Extrusion of soil				

<Comprehensive judgement>

Comprehensive judgement by inspector (NBRO)	I	Countermeasure	Outline	(Cause of phenomena, reason of judgement, urgency, repair method,etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		
Comprehensive judgement by facility administration organization	I	Countermeasure	Outline	(Cause of phenomena, schedule of repair, method of repair, cost estimation, reason of judgement, etc.)
	II	Detailed investigation		
	III	Continuous monitoring		
	IV	Record storage		

Sri Lanka
National Building Research Organization (NBRO)



Sri Lanka
National Building Research Organization (NBRO)

Monitoring Sheet

Photo

Date:

Affiliation: Name:

Site: Central Province	Matale District	Alagumale
Completed year: 2017	Location:	(shown in the map)

Photo 1:	Photo 2:
Photo 3:	Photo 4:
Photo 5:	Photo 6:

Appendix 8-10

Letter of land use permission

නගරාධිපති
மேயர்
Mayor
081-2222274

නියෝජ්‍ය නගරාධිපති
உதவி மேயர்
Deputy Mayor
081-2222870

නාගරික කොමසාරිස්
மாநகர ஆணையாளர்
Municipal Commissioner
081-2223921

නියෝජ්‍ය නාගරික කොමසාරිස්
உதவி மாநகர ஆணையாளர்
Deputy Municipal Commissioner
081-2225638

ඔබේ අංකය
உமது இல
Your No

මගේ අංකය
எனது இல
My No
CPC/KMC/WD/DO/04/2015

දිනය
திகதி
Date
2015.03.17

ස්ථානාධිපති

ජාතික ගොඩනැගිලි පර්යේෂණ සංවිධානය

මහනුවර දිස්ත්‍රික්කය

මහනුවර හෙදි පුහුණු පාසැල පිටුපස නාය යෑම

ඉහත කරුණට අදාළව ඔබ විසින් එවන ලද ඔබේ සමාංක හා 2015.03.11 දිනැති ලිපිය නා බැඳේ.

02. ඒ අනුව ලිපියේ සඳහන් ප්‍රදේශය තුල බෝගම්බර ක්‍රීඩාංගනය සහ ඇහැලේපොල කුමාරිහාමි මාවත පිහිටා ඇත. ඉදිරියේ නගර සභා අරමුදල් යොදවා ඇහැලේපොල කුමාරිහාමි මාවත සංවර්ධනය කිරීමට යෝජනා කර ඇත. එබැවින් එම දේපලවලට අවහිරයක් හෝ හානියක් සිදුනොවන පරිදි ඔබ ලිපියෙන් ඉල්ලා ඇති අකාරයට සංවර්ධන කාර්යයන් සිදු කිරීම සඳහා මහනුවර මහ නගර සභාවේ මහසභාවේ අනුමැතිය ලබා දෙන බව කාරුණිකව දන්වා සිටිමි.

චන්දන තෙන්නකෝන්

මහනුවර නාගරික කොමසාරිස්

Mr Hara
Approval has given by the Municipal Commisoner of Kandy Mitigation Council to conduct activities on Nurses Training School as we planned. You can conduct the work accordingly
25 03 2015

කාර්යාලය
காரியாலயம்
Office
081-2222275
081-4472368/69

ෆැක්ස්
தொலைநகல்
Fax
081-2225638
081-2223921
081-2223832

වෙබ් අඩවිය
இணையதளம்
Web site
www.kandycity.org

විද්‍යුත් තැපෑල
மின்அஞ்சல்
e-mail
kmckandy@sltnet.lk

Appendix 8-11

Report of environmental monitoring

Environmental monitoring of pilot project for landslide and rock fall mitigation work in Technical Corporation for Landslide Mitigation Project (TCLMP)

Financial Assistance by Japan International Cooperation Agency (JICA)

Progress Report on Environmental Compliance Monitoring TCLMP-7

July 2017

Prepared for:
Director
Landslide Research and Risk Management Division
National Building Research Organization
No 99/1, Jawatta Road
Colombo 05.

Prepared By:
Environmental Studies and Services Division
National Building Research Organization
No 99/1, Jawatta Road
Colombo 05

1. General details

1.1 Introduction

In the year 2013, 04 landslide affected sites, out of the 16 landslides prioritized under Integrated Landslide Mitigation Proposal (IMP), had been selected by JICA for supporting the mitigation. As a result, the Technical Cooperation for Landslide Mitigation Project (TCLMP) was commenced on October 01, 2014. Under the TCLMP, two natural landslides in Udamadura in Nuwara Eliya District, and in Badulusirigama in Badulla District and a rock fall threat in Alagumale in Matale District will be mitigated.

1.2 Projects administration details

Project Implementing Agency: National Building Research Organization (NBRO)
Funding Agency : Japan International Cooperation Agency

Mitigation site	Contractor
Badulusirigama landslide mitigation site Badulla	ELS Construction (Pvt) Ltd
Alagumale Rock fall mitigation site Matale	Sanguine Engineering (Pvt) Ltd
Udamadura Landslide mitigation site Nuwaraeliya	Geo Engineering consultants (Pvt) Ltd.

1.3 Scope of Environmental Monitoring

Environmental impacts are anticipated in the construction sites. During the mitigation of landslide, there may be impact of noise, dust, vibration, ecology and generation of waste during the process. Early identification of the major environmental impacts, rectify or mitigate them will help to reduce the negative impacts on the environment. In view of this, Landslide Research & Risk Management Division (LRRMD) of NBRO requested to the Environmental Studies and Services Division (ESSD) to monitor whether contractor is fulfilling Environmental regulations in the construction process.

1.4 Environmental Monitoring process

The environmental compliance monitoring process of ESSD is carried out under following

- Twice a month site inspections by Environment Officer of ESSD
- Instruct Officer In-charge/ Site Engineer of 4 projects on checklists that would be maintained by the contractor throughout the construction phase of the mitigation process.
- Checking environmental compliance by 38 indications under 8 categories (Checklist are annexed) impact on flora, fauna ecosystem and historical places
- Checking record keeping of contractor log books and checklists
- Raising noncompliance and give recommendations for rectification
- Preparation of inspection visit reports to LRRMD

1.5 Organization setup for Environmental Compliance Monitoring

Division: Environmental Studies and Services Division
Coordinator Environmental Monitoring: S.A.M.S. Dissanayake, Senior Scientist
Environmental Officer: V.D.W. Sumanasekara, Scientist/Environmental Officer

1.6 Site Inspection Detail

This report presents the Environmental monitoring of the Technical Corporation for Landslide Mitigation Project (TCLMP) at Matale - Alagumale, Nuwaraeliya - Udamadura and Badulla - Badulusirigama for the period from 11/07/2017 to 12/07/2017.

Date	Site	Inspected By	Witness
11/07/2017	Alagumale, Matale	VDW Sumanaseakara Environmental Officer, Scientist, ESSD/NBRO	Mr. Ashen, TO, LRRMD/NBRO
11/07/2017	Udamadura, Nuwaraeliya		-
12/07/2017	Badulusirigama, Badulla		Mr.Palitha, TO, LRRMD/NBRO

1.7 Project implementation status

The current construction phases in each site is given in the following table.

Location	Proposed Landslide Mitigation	Construction Phase
Badulusirigama, Badulla	Surface drainage improvement	Construction activities finished
Alagumale, Matale	Gabion wall	Construction activities finished
Udamadura, Nuwaraeliya	Surface drainage improvement, Gabion wall	Construction activities finished

2. Environmental Compliance Monitoring

Status of Environmental compliance monitoring in 3 sites are given in the following table.

	Site	Badulusirigama		Alagumale		Udamadura	
Item No	Item	NC	C	NC	C	NC	C
1	Impact on flora, fauna, ecosystem and historical places	0	2	0	2	0	1
2	Air Pollution Control	0	4	0	4	0	1
3	Noise pollution and Vibration Control	0	0	0	0	0	0
4	Water Source and Quality	0	5	0	3	0	3
5	Health and Safety	0	6	0	6	0	5
6	Traffic Management	0	0	0	0	0	2
7	Disruption to Public	0	2	0	1	0	3
8	Waste Management	0	4	0	4	0	4
	Total compliance status	0	23	0	20	1	18
	Status as %	**0**	**100.00**	**0**	**100.00**	**0**	**100.00**

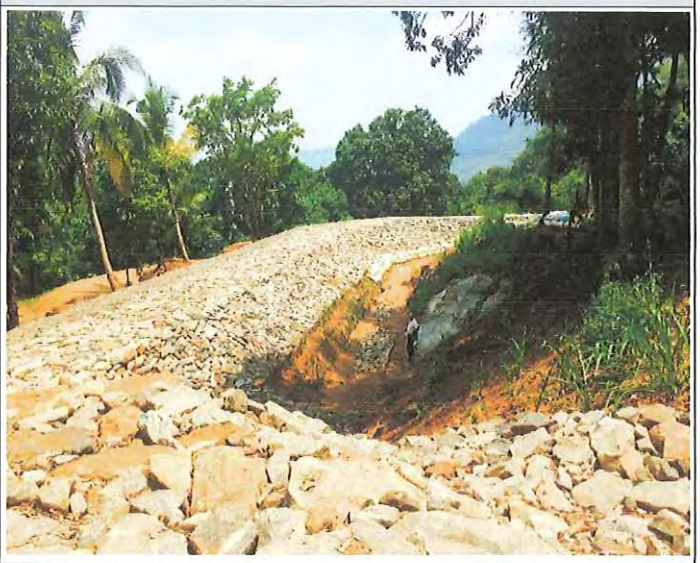
NC – Noncompliance C – Compliance

3. Observations on Environmental Noncompliance

3.1 Landslide mitigation work in Badulusirigama

Date inspected	Noncompliance Status	Photograph
12/07/2017	No any Noncompliance was observed during site visit.	 

3.2 Landslide mitigation work in Alagumale

Date inspected	Noncompliance Status	Photograph
11/07/2017	No any Noncompliance was observed during site visit.	 

3.3 Landslide mitigation work in Udamadura

Date inspected	Noncompliance Status	Photograph
11/07/2017	No any Noncompliance was observed during site visit.	 

4. Performance of Environmental Monitoring

Category	Satisfaction		
	Badulusirigama-Badulla	Alagumale-Matale	Udamadura-Nuwaraeliya
Removal of all debris, piles of unwanted earth, spoil material away from the work places	Satisfactory	Satisfactory	Satisfactory
Clearance of temporary structure and site clearance back to its former condition	Satisfactory	Satisfactory	Satisfactory
Clearance of raw material storage places, material preparation places and office space at the site	Satisfactory	Satisfactory	Satisfactory
Clearance of all drainage at the site if they were blocked	Satisfactory	Satisfactory	Satisfactory
Rehabilitation of all burrow pits/ areas clearly	Satisfactory	Satisfactory	Satisfactory
Rehabilitation of the temporary access roads	Satisfactory	Satisfactory	Satisfactory

Overall performance of environmental monitoring observed at 3 sites; Badulusirigama- Badulla, Alagumale- Matale and Udamadura-Nuwaraeliya during the site visit is satisfactory.

Inspected by
VDW Sumanasekara
Scientist
ESSD/NBRO

Checked by
S A M S Dissanayake
Coordinator/Environmental Monitoring
ESSD/NBRO

Approved by
S V Dias
Director
ESSD/ NBRO