

**A site visit report on Short and Long term mitigation measures for
landslides and land subsidence across Sirmaur district in the state of
Himachal Pradesh**

**Submitted to
Himachal Pradesh State Disaster Management Authority (HPSDMA)
Himachal Pradesh**



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Executive Summary

CSIR-CBRI team visited the identified landslide locations in Sirmaur District, Himachal Pradesh from 6th to 10th May 2024. The objective was to provide observations on possible causes for distress in slopes and to suggest possible remedial measures for slope stabilization. The officials visited seven (07) sub-divisions having twenty-two (22) landslide sites which needed urgent attention for implementing possible remedial measures. The report presents an overview of detailed observations of slides (approximate geometry, geology and probable causes) and associated risk elements on the slide zone. Also, the need for slope stabilization measures is highlighted in this report and probable mitigation measures for each slide zone are presented. First part of the report (pages: 1-24) describes collectively the time frame, scope of work, fund required and terms for the DPR preparation. Second part of the project (pages: 24-112) gives the site-specific observations, and project proposal for the preparation of detailed project report (DPR) of the individual landslides. CBRI is equipped with the state of the art, field and laboratory instrument facilities (Remote sensing, Drone, ERT, MASW, Triaxial, small- and large-scale direct shear, elementary equipment for soil characterizations etc.) and numerical software (FEM, FDM in 2D and 3D). The fund required for the DPR preparation as per proposed proforma is Rs. 8,43,00,000/- + applicable taxes. The overall time required for the same is six (6) months.

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1. Overall Introduction

With reference to letter no. Rev (DMC) (F) 11-09/2021-LM dated 15th September 2023, Deputy Commissioner, District Sirmaur (H.P.) requested Director, CSIR-CBRI, to depute a team of scientists for preliminary study of landslides and land subsidence in Sirmaur district (HP). The visit was planned to understand probable causes of slides, to assist state engineers in DPR preparation and for necessary guidance in developing measures for improving the stability of slopes in the 07 sub-divisions of Sirmaur district (H.P.). Accordingly, a team comprising of Dr. Manojit Samanta, Principal Scientist, Er. Koushik Pandit, Senior Scientist and Er. Shashank, Scientist from CSIR-CBRI, visited 22 selected landslide sites across Sirmaur district to understand the geological and geotechnical features of landside sites and to evaluate the need for stability measures to improve the slope sections. CSIR-CBRI team visited the affected sites from 6th to 10th May 2024 and interacted with district officials as well as affected villager/locals on ground. This visit also received wide publicity in the local media. Based on the observations at the site and discussions with the district administration officials, the team has prepared this report, which presents the possible causes for instability of slopes at the selected locations along with possible field control measures. In addition, the site visit report also details the effect on the nearby habitation.












Fig. 1 CSIR-CBRI Team interacting with district officials













Fig. 2 Wide publicity received by CBRI team in local media




2. Sites Visited

SI No.	Sub division	Land subsidence site	Panchayat	Remarks/Site photographs
1	Kaffota	Near bag Habra	Bhajon	
		Ambon & Jandniya	Chandni	
2	Pachhad	Thalpa	Naina Tikker	
		Lana Rauna	Neri nawan	



		Chunnar	Neri nawan	
3	Paonta Sahib	Katchi Dhang	Muglawal kartarpur, Sirmuari tal	
		Khatwar	Banor	
4	Nahan	Malgaon	Nehli Dheeda	
		Jarag	Jarag	

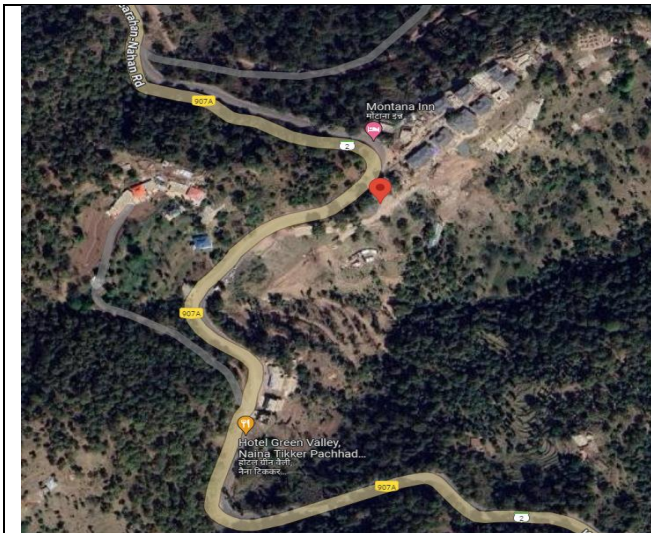
		Agdiwala	Mattar	
		Tirmali Dyar	Birla	
5	Rajgarh	Near Shalana	Shallana	
		Shalech Kanchi	Kotla Bangi	
		Near Kot	Kothia Jajar	

		Khairi Dhank	Dimber	
6	Shillai	Ganali	Millah	
		Bindoli	Ajroli	
7	Sangrah	Ungarkando	Rajana	
		Bounal	Bounal kakog	

		Gatta mandwach	Sangna	
		Harlog	Bhujond	
		Near petrol pump Charna	Charna	

3. Risk Elements

	
Bag Habra site, Kaffota subdivision (houses, residential building 7 land on head of slide)	Ambon & Jandniya site, Chandni Panchayat, Kaffota Subdivision (road & habitation near site)



Thalpa site, Naina Tikker panchayat, Village Majhgaon, Pachhad subdivision (habitation near site)



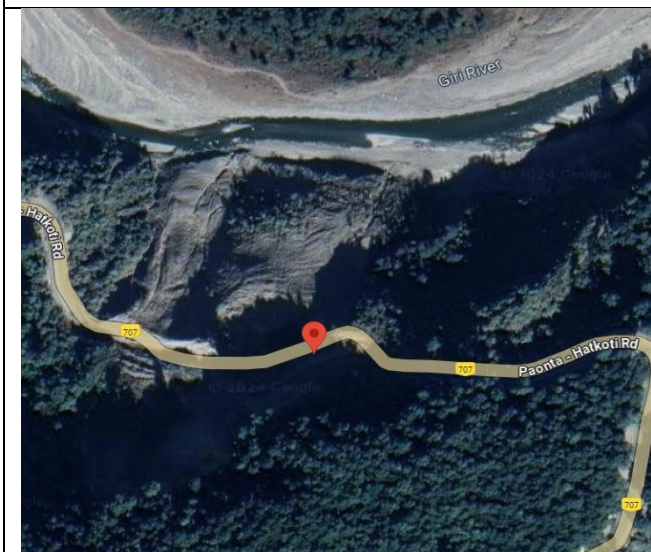
Lana Rauna site, Neri Nawar Panchayat, Pachhad Subdivision (road passing through slide zone)



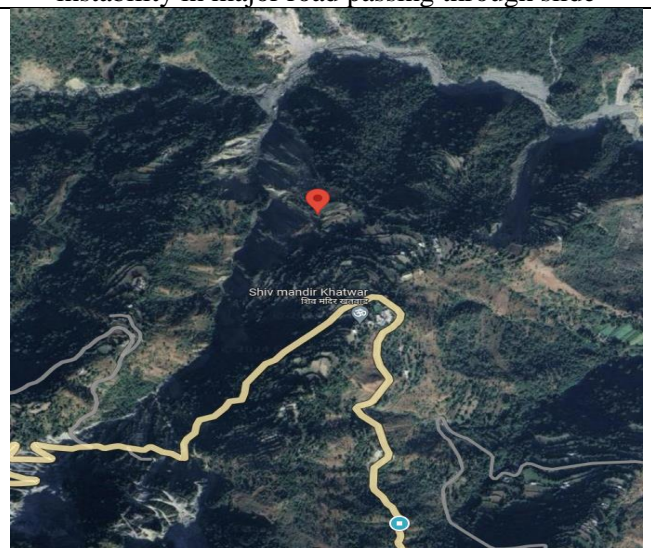
Chunnar site, Neri Nawar panchayat, Pachhad subdivision (road passing through slide zone)



Katchi Dhang NH-707 site, Village Sirmauri Tal, Paonta Sahib Subdivision (Chainage km 14+165), instability in major road passing through slide



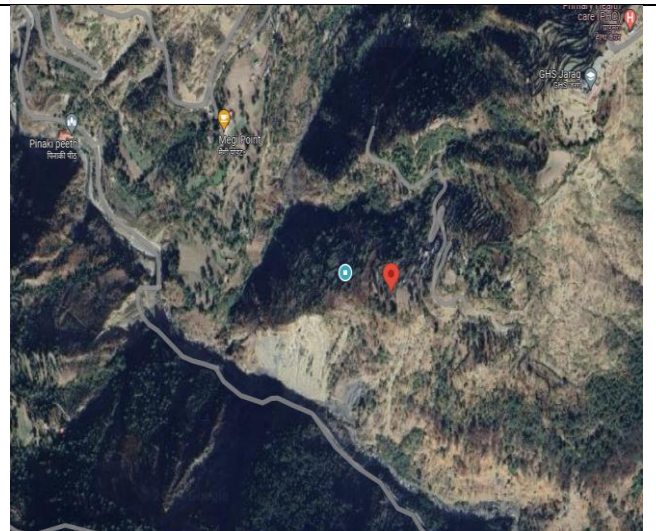
Katchi Dhang NH-707 site, Muqlawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision



Khatwar site, Banor Panchayat, Paonta Sahib Subdivision (habitation affected by slide)



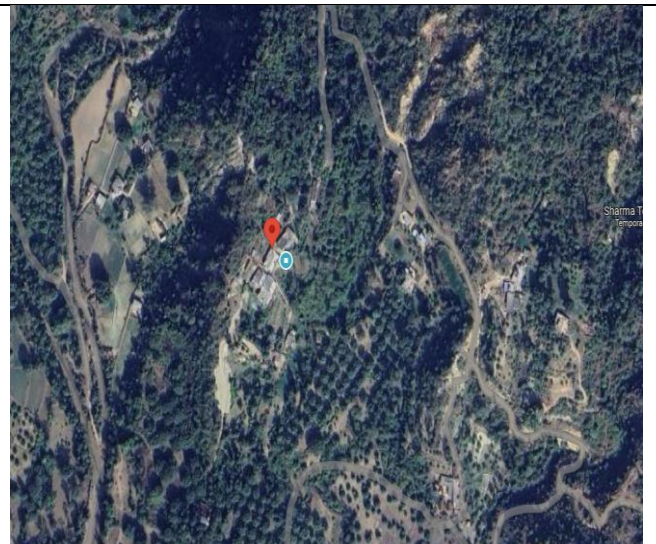
Malgaon site, Nehli Dheeda Panchayat, Nahan Subdivision



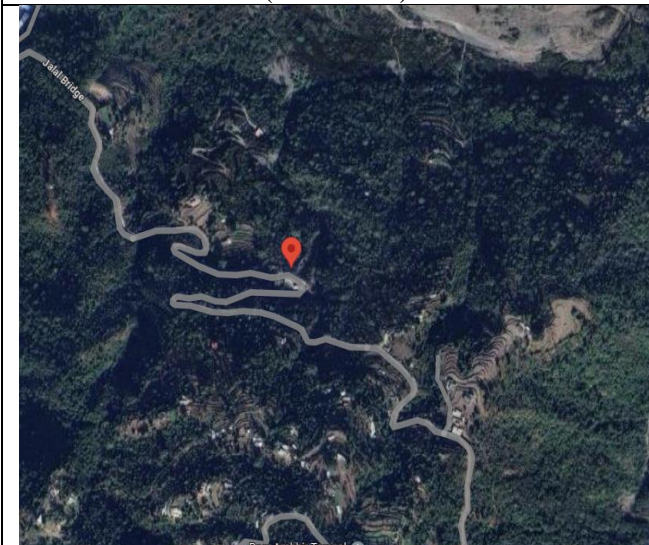
Jarag site, Nahan Subdivision (habitation visible)



Agdiwala site, Mattar panchayat, Nahan Subdivision (Location 1)



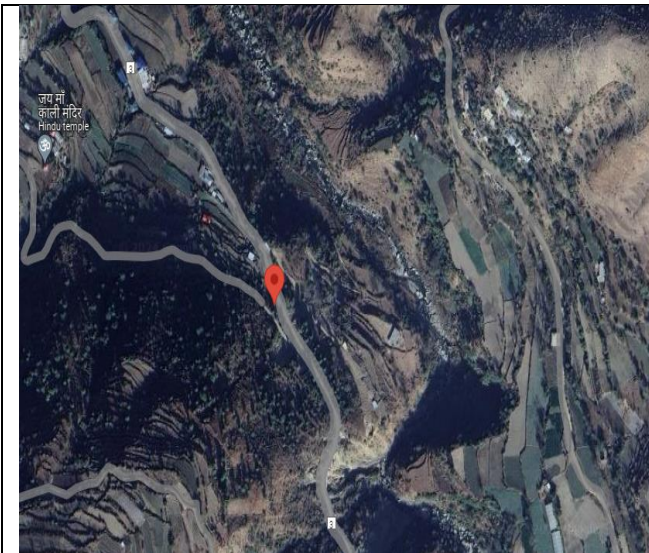
Agdiwala site, Mattar panchayat, Nahan Subdivision (Location 2), (habitation visible nearby)



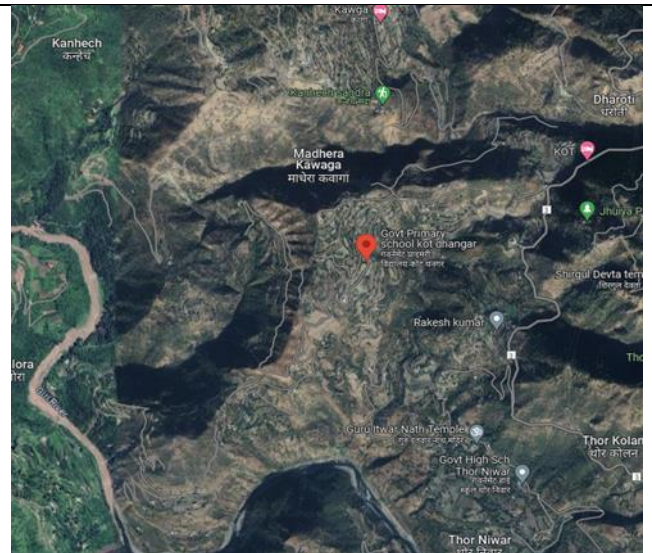
Tirmali Dyar site, Birla panchayat, Nahan Subdivision (slide affecting the road section, buildings)



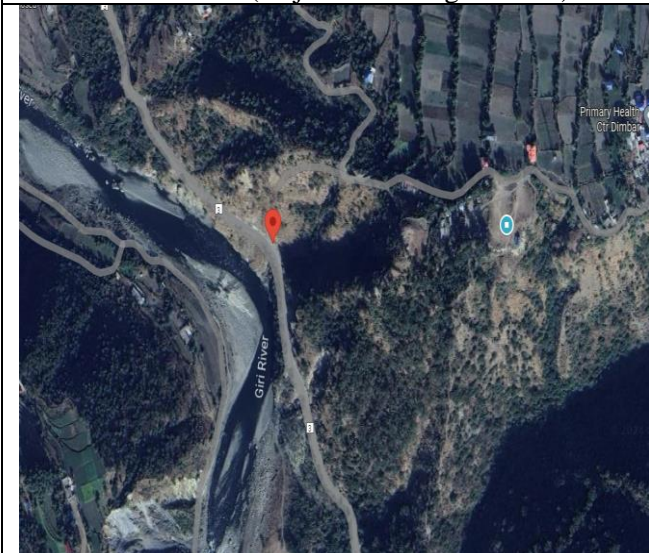
Shallana site, Rajgarh Subdivision (major road being affected)



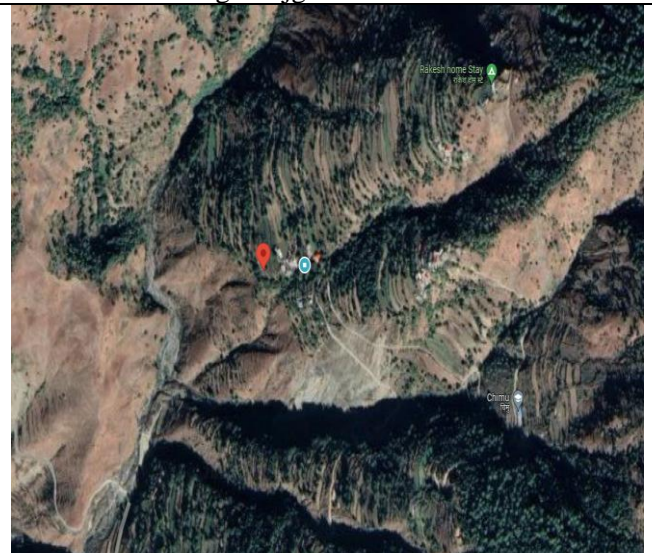
Shalech Kanchi site, Kotla Bangi Panchayat, Rajgarh Subdivision (major road being affected)



Near Kot site, Kothia Jajar Panchayat, Kot Dhangar village Rajgarh Subdivision



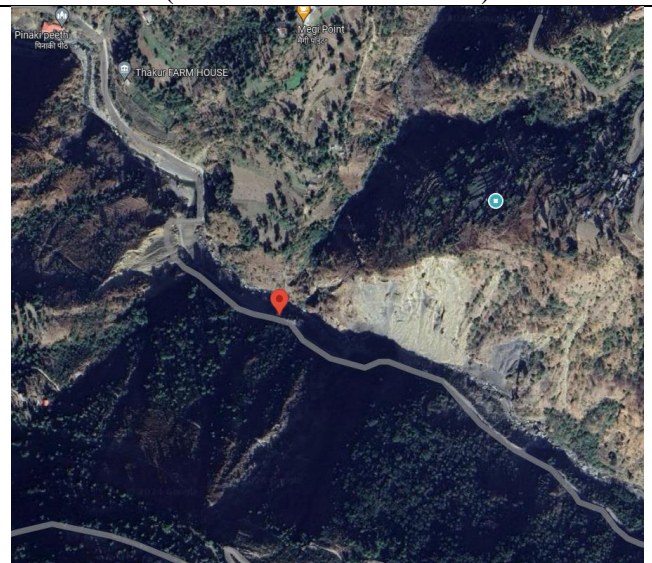
Khairi Dhank site, Dimber Panchayat, Rajgarh Subdivision (road passing through slide zone)



Ganali site, Millah Panchayat, Shillai Subdivision (affected habitation & land)



Bindoli site, Ajroli Panchayat, Shillai Subdivision (road section passing through slide & habitation)

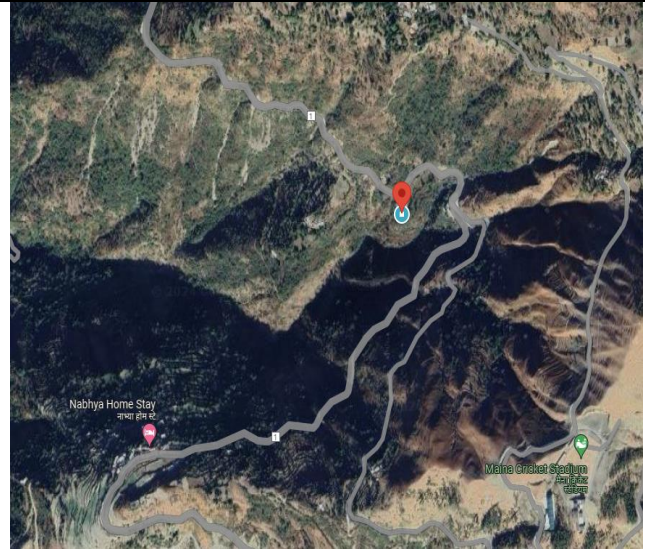


Ungarkando site, Rajana Panchayat, Sangrah Subdivision (Location 1)

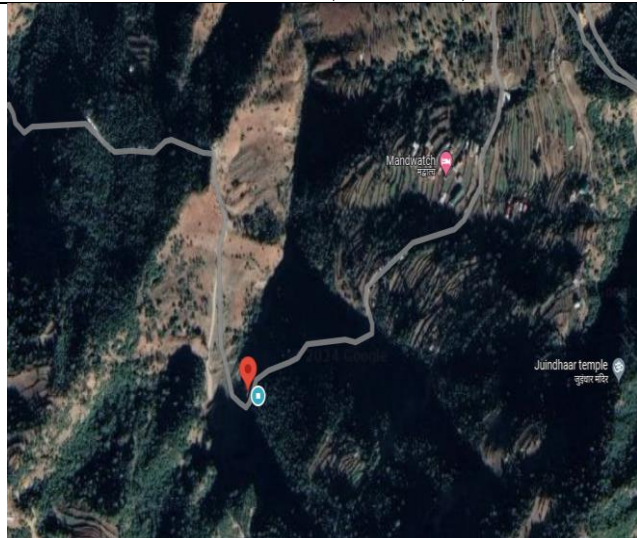
visible)



Ungarkando site, Rajana Panchayat, Sangrah Subdivision (Location 2)



Bounal site, Bounal Kakog Panchayat, Sangrah Subdivision



Gatta Mandwach site, Sangrah Subdivision (road section passing through slide)



Harlog site, Bhujond panchayat, Sangrah Subdivision (road section passing through slide)



Charna petrol pump site, Sangrah Subdivision

4. Priority List of slides for DPR preparation

Based on different parameters e.g. number of houses under distress, number of inhabitants affected, acreage of agricultural land affected, importance of road passing through slide zone as well as geometrical and geological conditions of the landslide and other factors, they have been accorded a priority. The list of slides along with priority for DPR preparation is as follows,

Table 1 Table indicating risk elements and DPR preparation priority

Location	Risk elements	Priority for DPR preparation
Bag Habra site, Kaffota subdivision	Agricultural land, source for Debris flow at Ambon & Jandniya site, Damming of river, effect on local school buildings and 2 villages	Recommended/ High
Ambon & jandniya site, Kaffota subdivision	Lake formation at crest, affects state highway. Housing, farmland damaged. Affects nearby infrastructure	Recommended/ High
Thalpa site, Naina Tikker panchayat, Village Majhgaon, Pachhad subdivision	Local houses, agricultural land on the valley side. 4 buildings directly affected and 10-12 buildings partially affected	Recommended/ Medium
Lana Rauna site, Neri Nawan panchayat, Pachhad subdivision	Blockage of major district road affecting 35-40 families	Recommended/ High
Chunnar site, Neri Nawan panchayat, Pachhad subdivision	8-10 houses directly affecting slide. Road stability in danger due to river cutting	Recommended/ High
Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision (Chainage km 14+165)	National Highway NH-707 affected. 2-3 residential structures on the valley side	Recommended/ High
Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision	Affects National Highway NH-707. Possibility of toe cutting by river	Recommended/ High
Khatwar site, Banor Panchayat, Paonta Sahib Subdivision	Numerous habitations & agricultural land affected. Cracks in residential buildings	Relocation of inhabitants may be considered.
Malgaon site, Nehli Dheeda Panchayat, Nahan Subdivision	Village road and effect on 3-4 houses	Recommended/Low (PWD already working)

Jarog site, Nahan Subdivision	20-25 houses at top of slide and a couple of houses on the valley side of slide	Recommended/ High
Agdiwala site, Mattar panchayat, Nahan Subdivision	Effect on agricultural land. 6-7 houses affected by ground movement	Recommended/ Medium
Tirmali Dyar site, Birla panchayat, Nahan Subdivision	Major district road and 2-3 multistory buildings on the hill side.	Recommended/ Medium
Shallana site, Rajgarh Subdivision	Major district road and 2-3 buildings near slide area	Recommended/ Medium
Shalech Kanchi site, Kotla Bangi Panchayat, Rajgarh Subdivision	State highway through slide zone and school on the valley side	Recommended/ High
Near Kot site, Kothia Jajar Panchayat, Kot Dhanger village Rajgarh Subdivision		Recommended/ Medium
Khairi Dhank site, Dimber Panchayat, Rajgarh Subdivision	Major road passing through slide zone	Recommended/ Medium
Ganali site, Millah Panchayat, Shillai Subdivision	15-16 houses near slide zone. Effect on agricultural land	Recommended/ High
Bindoli site, Ajroli Panchayat, Shillai Subdivision	Major district road passing through slide. Affects 15-20 buildings and agricultural land. Villages already experiencing settlement	Recommended/ High
Ungarkando site, Rajana Panchayat, Sangrah Subdivision	Location of state highway, massive slide and thick debris layer	Recommended/ High
Bounal site, Bounal Kakog Panchayat, Sangrah Subdivision	Major district road passing through slide and affecting 3-6 houses and shops	Recommended/ Medium
Gatta Mandwach site, Sangrah Subdivision	Major road passing through the slide area	Recommended/ Low
Harlog site, Bhujond panchayat, Sangrah Subdivision	State highway passing through affected area. 5-6 houses located near slide zone	Recommended/ High
Charna petrol pump site, Sangrah Subdivision	Major road, high stresses & jointed rock mass	Recommended/ Low

5. General Observations

During the site visits, it was found that the existing slope sections experiencing excessive subsidence and distress due to non-engineered structural loading, inadequate slope protection and drainage measures. No proper slope protection and drainage measures were seen at most of the visited sites. Furthermore, the slope sections were located either on a major road where traffic movement was regular and continuous throughout the day or they directly affected residential buildings and agricultural land. In some places, the highway section failed due to slope failure. At most of the places, the geology of the slope contains highly fractured rock mass with a mixture of rock debris with loose soil deposits. In addition to landslides, the visited sites also posing rock fall & debris flow hazards at some portions. It was understood that some portion of the visited sites contains existing nallahs which also contributed in affecting the stability of slope through infiltration and generation of pore water pressures. Further, in monsoon seasons, the infiltrated water and surface runoff water possibly induces instability to the slope section. To minimize the hazards, measures such as rockfall protection, drainage, construction of retaining wall/ gabion wall and other slope stabilization measures needs to be implemented to improve the stability of the slope. Implementation of these measures will minimize distress and subsidence at the locations.

6. Brief details of Landslides

Location	Slope characteristics (Geometry, Length, width, average slope angle etc.)			Location coordinates	Slope material characteristics	Type of landslide	Possible problem identification	Probable remedial measures	Annexure
	Height of slope	Width of slide	Slope angle						
Bag Habra site, Kaffota subdivison	Height of slope varying from 700-1500 m .	Width of slide was approximately 250 m	Slope angle is between 65° to 80°	30°34'52.3"N , 77°33'22.9"E	Highly disintegrated rock mass and soil fines mix with boulder	Chronic	Low Shear strength of strata, water saturation during rains	Slope stabilization measures (Benching, Anchors, wire mesh, shotcreting, Bioengineering, retaining structures etc.) to minimize slope movement. Provision of drainage holes, catch drains and culverts	A.1
Ambon & jandniya site, Kaffota subdivision	Height of slope varying from 700 m on hill side and 500 m on valley side.	Width of site is approximately 500-600 m	Moderate slope between 20° to 45°	30°34'25.6"N, 77°32'48.3"E	Slope consists of debris material with some fines.	Chronic	Debris material, lake formation at top, high water ingress in slope during rains	Installation of Debris flow barriers & retaining structures etc. to minimize slope movement. Provision of drainage holes, drainage paths, culverts etc.	A.2
Thalpa site, Naina Tikker panchayat, Village Majhgaon, Pachhad subdivision	Height of slope varying from 25-30 m on hill side and 70-80 m on valley side.	Width of site is approximately 70-80 m	Steep slope between 60° to 75°	30°47'46.8"N , 77°07'33.7"E	Slope consists of debris and soil mix boulders	Not chronic	High building load on slope, water ingress in slope during rains	Anchors, Bioengineering, retaining structures to arrest slope movement. Building condition survey (BCS) for nearby affected structures. Provision of drainage holes, drainage paths, culverts etc.	B.1

Lana Rauna site, Neri Nawan panchayat, Pachhad subdivision	Height of slope around 100 m high on hill side and 400 m on valley side.	Width of site is approximately 800 m	Steep slope between 60° to 75° on both hill and valley sides	30°48'02.9"N, 77°15'36.2"E	Highly disintegrated rock mass and major presence of fines materials	Chronic from last 25-30 years	Low shear strength of strata, Water ingress in slope during rains and inadequate drainage, Toe cutting by Giri river during rains	Anchors, grouting Bioengineering, Geosynthetic retaining structures to arrest slope movement. Rock fall barriers for rock fall protection. Building condition survey (BCS) for nearby affected structures. Provision of drainage holes, drainage paths, culverts etc. River training works on valley side. Continuous monitoring & relocation and emergency evacuation plans	B.2
Chunnar site, Neri Nawan panchayat, Pachhad subdivision	Height of slope around 1000 m high on hill side and 5-10 m on valley side.	Width of site is approximately 1500 m		30°46'31.6"N, 77°17'48.3"E	Debris & Talus on hill side, Highly disintegrated rock mass and major presence of fines materials	Not chronic, from last 5-10 years	Low shear strength of strata, Water ingress in slope during rains and inadequate drainage, Toe cutting by Giri river during rains	Anchors, grouting Bioengineering, retaining structures to arrest slope movement. Rock fall barriers for rock fall protection. Building condition survey (BCS) for nearby affected structures. Provision of drainage holes, drainage paths, culverts etc. River training works on valley side. Continuous monitoring of slope & relocation and emergency evacuation plans	B.3

<p>Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision (Chainage km 14+165)</p>	<p>Height of slope around 30 m on hill side and 70-80 m on valley side.</p>	<p>Width of site is approximately 300 m</p>	<p>Moderately Steep slope between 60° to 75°</p>	<p>30°32'42.1"N, 77°38'45.2"E</p>	<p>Jointed rock mass overlain by soil mix boulder (mostly on hill side), highly sheared rock mass on valley side</p>	<p>Not chronic</p>	<p>Presence of loosened rock joints and debris on hill side slope, water ingress in slope during rains, Toe instability on valley side</p>	<p>Rock nets, Self-drilling anchors (SDA's), Bioengineering, masonry retaining structures to arrest slope movement. Debris fencing near outfall. Provision of drainage holes, drainage paths, culverts etc. along the slide</p>	<p>C.1</p>
<p>Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision</p>	<p>Height of slope around 50 m on hill side and 30 m on valley side.</p>	<p>Width of site is approximately 450 m</p>	<p>Moderate to quite Steep slope between 70° to 80°</p>	<p>30°32'55.0"N, 77°38'19.3"E</p>	<p>Very blocky to highly disintegrated rock mass (mostly on hill side), Debris material on valley side</p>		<p>Presence of highly sheared & disintegrated rock mass and debris on the slope, water ingress in slope during rains, Toe instability on valley side slope caused by river erosion</p>	<p>Rock nets, Self-drilling anchors (SDA's), Bioengineering, masonry retaining structures to arrest slope movement. Provision of drainage holes, drainage paths, culverts etc. along the slide. Provision of river training works for valley side slope</p>	<p>C.2</p>
<p>Khatwar site, Banor Panchayat, Paonta Sahib Subdivision</p>	<p>Height of slide around 600-700 m.</p>	<p>Width of site is approximately 500 m</p>	<p>Moderate to quite Steep slope between 70° to 80°</p>	<p>30°35'54.6"N, 77°43'35.2"E</p>	<p>Debris materials, highly disintegrated rock mass and boulders</p>		<p>Presence of highly sheared & disintegrated rock mass and debris on the slope, water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings and crop watering of agricultural land</p>	<p>Regular monitoring & emergency evacuation and rehabilitation plans. Relocation of inhabitants from site may be considered</p>	<p>C.3</p>

Malgaon site, Nehli Dheeda Panchayat, Nahan Subdivision	Height of slide around 50 m on hill side and 50 m on valley side	Width of site is approximately 50 m	Moderate Steep slope between 50° to 70°	30°36'52.7"N , 77°22'04.3"E	Fine soil with Debris materials, boulders		Water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings	Work is already going on at site by state department	D.1
Jarog site, Nahan Subdivision	Height of slide around 1500 m on valley side	Width of site is approximately 2000-2500 m	Steep slope between 60° to 80°	30°38'09.9"N , 77°28'03.0"E	Highly disintegrated rock mass overlain by a thick layer of soil mix boulder matrix	Not chronic	Water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings & crop watering on slope, Toe cutting by river	Provision of drainage holes, drainage paths, culverts etc. along the slide. River training works at toe, Piling near terrace, Self-drilling anchors, Retaining structures, bioengineering etc. Building condition survey (BCS) for existing infrastructure, Regular monitoring of slope, emergency evacuation and rehabilitation plans	D.2
Agdiwala site, Mattar panchayat, Nahan Subdivision	Height of slide around 100 m , Length of site is approximately 1000-2000 m at location 1	Height of slide around 30-50 m , Length of site is approximately 150-250 m at location 2	Moderately Steep slope between 60° to 80°	30°28'11.9"N, 77°22'56.9"E (Location 1) and 30°28'09.3"N , 77°22'45.4"E (Location 2)	Low plasticity clay and silt, sand	Not chronic	Water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings & crop watering on slope	Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, Retaining structures, bioengineering etc. Building condition survey (BCS) for existing infrastructure, Regular monitoring of slope, emergency evacuation and rehabilitation plans	D.3

Tirmali Dyar site, Birla panchayat, Nahan Subdivision	Height of valley side slope around 15-20 m , height of hill side slope around 100 m.	Length of site is approximately 300 m.	Moderately Steep slope of 60°	30°35'15.8"N , 77°26'41.7"E	Fines with debris material, boulders	Not chronic	Water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings & toe cutting by river	Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, rock net Reinforced earth & Retaining structures, bioengineering etc. Building condition survey (BCS) for existing infrastructure,	D.4
Shallana site, Rajgarh Subdivision	Height of valley side slope around 200-300 m , height of hill side slope around 700-1000 m. .	Length of site is approximately 200 m	Moderately Steep slope of 60°	30°50'16.4"N, 77°17'50.1"E	Debris material and soil mix with boulder overlain over highly disintegrated rock mass.		Water ingress in slope during rains, Low shear strength of strata, Boulder outcrops and long slope without much vegetation	Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, rock net & Retaining structures, bioengineering, River Training works etc. Debris flow barrier and rock fall barrier	E.1
Shalech Kanchi site, Kotla Bangi Panchayat, Rajgarh Subdivision	Height of valley side slope around 70-80 m , height of hill side slope around 70-80 m.	Length of site is approximately 150 m.	Moderately Steep slope angle varying between 60 - 70°	30°57'18.5"N, 77°19'36.2"E	Predominantly fine soil mixed with debris material underlain by blocky rock mass	Recent	Water ingress in slope during rains, Low shear strength of strata, Boulder outcrops and long slope without much vegetation	Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, rock net & Retaining structures, bioengineering etc. Debris flow barrier and rock fall barrier	E.2
Near Kot site, Kothia Jajar Panchayat, Kot Dhanger village Rajgarh Subdivision	Height of valley side slope around 70-80 m , height of hill side slope around 70-80 m.	Length of site is approximately 150 m.	Moderately Steep slope angle varying between 60 - 70°		Very blocky rock mass		Water drainage problem at site and major water seepage at site	Provision of drainage holes, drainage paths, culverts etc. along the slide. Hydrological mapping for water source	E.3

Khairi Dhank site, Dimber Panchayat, Rajgarh Subdivision	Height of valley side slope around 1000 m , height of hill side slope around 200 m.	Length of site is approximately 200 m.	Moderately Steep slope angle varying between 60 - 70°	30°46'52.4"N ,77°17'51.7"E	Very blocky phyllite rock mass		Blocky & loose rock mass, Toe cutting at base by river, Water ingress in joints through slopes	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining structures on valley side, river training works at toe of slide. Rock bolts and rock nets on the hill side. Debris fence and rock fall barrier	E.4
Ganali site, Millah Panchayat, Shillai Subdivision	Height of valley side slope around 300 m.	Length of site is approximately 100 m.	Moderately Steep slope angle varying between 45 – 60°	30°41'35.7"N , 77°38'43.1"E	Predominantly soil along with debris material and boulders		Loose strata, Water ingress in slopes and tension cracks, building load on slope, improper drainage from houses, crop watering	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining structures on valley side, Monopiles and grouted rock anchors, Building condition survey (BCS) of the existing buildings, regular monitoring & emergency evacuation & rehabilitation of the habitants	F.1
Bindoli site, Ajroli Panchayat, Shillai Subdivision	Height of hill and valley side slope around 300 m.	Length of site is approximately 800-1000 m.	Moderately Steep slope angle varying between 50 – 70°	30°46'23.7"N , 77°38'15.7"E	Debris material underlain with highly disintegrated rock mass	Not Chronic	Loose strata, Water ingress in slopes and tension cracks, Toe cutting by water stream, Boulder outcrops and debris on slope having minimal vegetation	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structures on valley side, Self-drilling anchors, rock net and wire mesh on hill side. River training works near toe of slope and bioengineering. Debris flow and rock fall barrier	F.2

Ungarkando site, Rajana Panchayat, Sangrah Subdivision	Height of hill and valley side slope around 100 m and 700 m respectively. Length of site is approximately 200 m. (Location 1)	Height of hill and valley side slope around 300 m and 50 m respectively. Length of site is approximately 200-250 m. (Location 2)	Moderately to quite Steep slope angle varying between 40 – 70°	30°38'05.8"N, 77°27'47.1"E (Location 1); 30°37'21.1"N, 77°27'45.8"E (Location 2)	Debris material underlain with highly disintegrated rock mass	Water ingress in slopes and tension cracks, Toe cutting by water stream, Boulder outcrops and debris on slope	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structures on valley side, Self-drilling anchors, rock net and wire mesh on hill side. River training works near toe of slope and bioengineering. Debris flow and rock fall barrier	G.1
Bounal site, Bounal Kakog Panchayat, Sangrah Subdivision	Height of hill and valley side slope around 70 -80 m and 60-70 m respectively.	Length of site is approximately 200 m.	Moderately to quite Steep slope angle varying between 40 – 70°	30°38'52.0"N, 77°26'26.0"E	Debris material underlain with highly disintegrated rock mass	Water ingress in slopes and tension cracks, low shear strength of strata, unstable geometry	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structures on valley side, Self-drilling anchors, netting and bioengineering on hill side.	G.2
Gatta Mandwach site, Sangrah Subdivision	Height of hill and valley side slope around 250 m and 150-200 m respectively.	Length of site is approximately 500 m.	Moderately steep slope angle varying between 50 – 60°	30°42'42.2"N, 77°35'10.2"E	Debris material underlain with highly disintegrated rock mass	Water ingress in slopes and tension cracks, low shear strength of strata, unstable geometry	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structures & bioengineering on valley side, Self-drilling anchors, netting and bioengineering on hill side. Provision for rock fall barrier	G.3
Harlog site, Bhujond panchayat, Sangrah Subdivision	Height of hill and valley side slope around 150-160 m and 250 m respectively.	Length of site is approximately 500 m	Moderately steep slope angle around 50°	30°44'10.0"N, 77°24'08.0"E	Debris material underlain with highly disintegrated rock mass	Water ingress in slopes and tension cracks, low shear strength of strata, unstable geometry	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structure on valley side, Self-drilling anchors, netting on hill side. Provision for rock fall barrier	G.4

Charna petrol pump site, Sangrah Subdivision	Height of hill and valley side slope around 400-500 m and 250 m respectively. .	Length of site is approximately 300 m	Quite steep slope angle around 75 - 85°		Highly jointed rock mass on hill side. Thin layer of debris on valley side		Water ingress in slope, highly jointed rock mass, stressed ground conditions, unstable geometry	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining structure on valley side; Rock bolts, Self-drilling anchors, netting on hill side. Provision for rock fall barrier	G.5
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7. Some Recommended Testing/Analysis Field Testing

- i. Drone Survey/Mapping
- ii. Geological and geotechnical site investigations
- iii. Site specific geophysical investigation
- iv. Detailed Laboratory Testing on obtained in-situ disturbed and undisturbed samples
- v. Numerical investigation/Numerical analysis based on the field and laboratory observations for assessing stability of slope with and without control measures

8. Total Cost: The charges for the above assignment will be Rs. 8,43,00,000/- + applicable taxes (18%). These charges are worked out according to prevailing guidelines of Council of Scientific & Industrial Research (CSIR), New Delhi, of which CBRI is a constituent establishment. These charges include expenses on manpower, TA/DA, transport, equipment, consumables & services, laboratory & computer usages, incidental expenses and institutional overheads. The total amount is to be sent to “Director, Central Building Research Institute, Roorkee” by electronic transfer only. Our bank details are: Bank Account No.: 30269847968, State Bank of India, Branch: CBRI, Roorkee, IFSC Code: SBIN0010635. Our GST No. is 05AAATC2716R1ZL.

9. Time Frame: Six months after the receipt of the project cost.

10. Terms and Conditions

- ☞ The field tests and any soil/rock exploration, if necessary, will be conducted by third party under the technical guidance and supervision of CSIR-CBRI. The payment to the third party will be made by Client.
- ☞ Previous geotechnical data of the study area and other necessary details of the proposed site need to be provided by PWD/SDMA.
- ☞ During the course of investigation at site, an engineer of PWD shall be in contact with the CSIR-CBRI team of scientists for providing easy access to site, geotechnical investigation, slope stability assessment execution etc.
- ☞ PWD will provide all relevant information available with them about the site conditions and be available for discussions.
- ☞ Accommodation and local transport should be provided by PWD for team of CSIR- CBRI scientists during their site visit.
- ☞ CSIR-CBRI will furnish three copies of the report consisting of the contents outlined under

the Scope of Work.

- ☞ CSIR-CBRI will be accessible for technical discussion on the work. The responsibility of CSIR-CBRI will be limited to technical matters only on the basis of data collected by CSIR-CBRI and information provided by the sponsor. Any legal/contractual obligations on account of implementation of the recommendations will be the responsibility of the users of the report.
- ☞ For dissemination of the knowledge, CSIR-CBRI reserves the right to publish any technical paper on the investigations carried out in any national/international journals or proceedings of symposia, unless specifically requested by the sponsor otherwise.

Site Specific Observations, Slope Characteristics, nearby habitations and Probable Remedial Measures

Annexure A.1

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Bag Habra site, Bhajon Panchayat, Kaffota Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Bag Habra in Bhajon panchayat, Kaffota subdivision, Sirmaur district, Himachal Pradesh. The existing slope is approximately 15 m to 20 m in height covered with highly disintegrated rock mass and fine material. The slope was quite steep with slope angle varying from 65° to 80°. The approximate width of the sliding portion was about 250 m.

Observations at the site:

The landslide was observed to be of larger in size and the region constitutes local houses, residential buildings and farmlands on the crest portion of the slope. As informed by locals, the slide zone is vulnerable, unstable and frequent landslides occurring at regular intervals. Presence of tension cracks were observed on site indicating progressive slope failure. No slope protection and drainage measures were present at site. It was informed by nearby residents and accompanying officials that the sliding problem is chronic at this location. It was also noticed that large volume of slide materials could potentially developed damming below the hill which possible creates artificial water storage during rains and can possibly contribute to debris flow at the visited location (Annexure A.2). Precipitation accompanied by anthropogenic activities shall cause further instability. In particular, during rains; water ingress through exposed slope faces and tension cracks will make the slope even more unstable.

Figures 1-6 show photos taken during the visit at the existing site location. The CSIR-CBRI team informed the officials about the necessity of slope protection measures and drainage in slope stability. Some possible control measures such as anchoring, construction of retaining wall and its interaction in stabilizing the slope were explained to the officials during the visit



Fig. 1 Residential buildings and agriculture on the top of landslide



Fig. 2 Disintegrated rock mass and soil fines with boulders in strata



Fig. 3 Tension cracks observed on top of slide



Fig. 4 Massive hill cutting caused due to landslide



Fig. 5 Continued loss of land



Fig. 6 Large volume of debris material may cause blocking and damming of water below the hill and may contribute to debris flow

Conclusions based on site observations

The existing slope is of larger dimensions, chronic and potentially unstable. Considering the vulnerability characteristics of the slope, regular monitoring and development of control measures etc. needs to be carried out for ensuring slope stability, emergency evacuation and also for rehabilitation. Proper and scientific drainage of water from nearby habitations and during rains is also necessary to minimize water intrusion within the slope to ensure long term slope stability. A combination of slope protecting measures e.g. benching, installation of anchors, wire meshes, bioengineering measures, debris barriers and retention techniques (e.g. gabion walls, retaining walls) are needed at site to arrest slope instability and to minimize associated debris flow in the valley. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Bag Habra site, Kaffota sub-division

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slope varying from 700-1500 m ○ Width of slide was approximately 250 m ○ Slope angle is between 65° to 80°
Location coordinates	30°34'52.3"N , 77°33'22.9"E

Slope material characteristics	Highly disintegrated rock mass and soil fines mix with boulder
Type of landslide	Chronic
Possible problem identification	Low Shear strength of strata, water saturation during rains
Probable remedial measures	Slope stabilization measures (Benching, Anchors, wire mesh, shotcreting, Bioengineering, retaining structures etc.) to minimize slope movement. Provision of drainage holes, catch drains and culverts

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be five (5) months.

Project Cost

The charges for the above assignment will be Rs. 46, 00,000/-+ taxes as applicable (18%)

Annexure A.2

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Ambon & Jandniya site, Chandni Panchayat, Kaffota Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Ambon & Jandniya in Chandni panchayat, Kaffota subdivision, Sirmaur district, Himachal Pradesh. The existing debris slope was about 700 m height on the hill side and 500 m down on the valley side. The slope was moderate with slope angle varying from 30° to 45°. The approximate width of the sliding portion was about 500-600 m.

Observations at the site:

This site consists of disintegrated debris material as sub-surface and surface strata. Further as per local officials and residents, small lake formation happens at the top during rains. It was observed that, water along with high volume of debris material has initiated soil water matrix on the slope causing debris flows and damaging infrastructure and affecting the road traffic on the passing state highway. The occurrence debris flow also affects local houses and farmlands, and a nearby school building posing high risk in nearby two villages. The problem was found to be chronic and has been there continuous since around 1975-1980. It was observed that. The average approximate depth of debris material will be not more than 5.0 m. It was also confirmed in the site that, no debris flow barriers, slope protection or drainage measures were present at the location. It was also noticed that debris material located at Bag Habra landslide (Annexure A.1) may act as possible source for the debris flow at the site. Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and importance of debris flow barriers.

	
<p>Fig. 1 State highway passing through affected area</p>	<p>Fig. 2 Debris flow material on the hill side slope</p>
	
<p>Fig. 3 Buildings present on valley side of debris flow</p>	<p>Fig. 4 Lake formation on hill side causing debris flow</p>

Conclusions based on site observations

The existing slope is subjected to chronic debris flow problem that becomes more severe during rains. This debris flow affects very important state highway and some houses and school. In order to mitigate this debris flow problem, adequate drainage paths are required to be provided on the affected slope and lake formation at top has to be prevented. Further debris flow barrier along with some retaining structures etc. can be used to stabilize the slope and to keep the road motor able. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Ambon & Jandniya site, Chandni Panchayat, Kaffota Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slope varying from 700 m on hill side and 500 m on valley side . ○ Width of site is approximately 500-600 m ○ Moderate slope between 20° to 45°
Location coordinates	30°34'25.6"N, 77°32'48.3"E
Slope material characteristics	Slope consists of debris material with some fines.
Type of landslide	Chronic
Possible problem identification	Debris material, lake formation at top, high water ingress in slope during rains
Probable remedial measures	Installation of Debris flow barriers & ring structures etc. to minimize slope movement. Provision of drainage holes, drainage paths, culverts etc.

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 36, 00,000/-+ taxes as applicable (18%)

Annexure B.1

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Thalpa site, Naina Tikker Panchayat, Village Majhgaon Pachhad Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Thalpa in Naina Tikker panchayat, Village Majhgaon, Pachhad subdivision, Sirmaur district, Himachal Pradesh. The site is a major distress point owned by a private party on which slope instability has been observed.

Observations at the site:

Private construction on hill side consists of multistory building that shall exert high load on the slope and may create instability. Some mitigation work was observed at site i.e. use of anchors, retaining walls, rock nets, by use of drainage pipes etc. The sub strata consist of combination of debris materials and soil mixed with boulders. On the valley side portion, local houses and agricultural land was observed. In addition, buildings were also observed along the slip portion of the slope. The site experienced instability along the hill side and valley side. Due to this, continuous monitoring is highly required in this region to minimize the landslide induced risk on the adjoining settlements. Nearly, about 4 buildings have been directly affected and 10-12 buildings may be affected partially.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage, slope stabilization measures and building condition surveys.



Fig. 1 Mitigation work on hill side slope of the property



Fig. 2 Both hill and valley side instability and high building loads on slope



Fig. 3 Buildings present on fringes of slope



Fig. 4 Agricultural land and structures existing on valley side

Conclusions based on site observations

High building loads are being exerted on the slope, with in adequate mitigation measures. The implementation needs to be inspected for assessing its effectiveness in slope protection. Providing drainage holes in slopes, catch drains and drainage paths is of utmost importance which is highly required in these types of slopes. The drained water should be properly collected and taken down the hills using culverts to ensure site stability and to minimize intrusion. Further Building Condition Survey (BCS survey) may be done to assess the structural health of already affected buildings near the slide. Buildings near fringes of the landslide may be further protected by use of retaining structures and slope stabilization measures etc. on the valley side. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Thalpa site, Naina Tikker panchayat, Village Majhgaon, Pachhad subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slope varying from 25-30 m on hill side and 70-80 m on valley side . ○ Width of site is approximately 70-80 m ○ Steep slope between 60° to 75°
Location coordinates	30°47'46.8"N , 77°07'33.7"E
Slope material characteristics	Slope consists of debris and soil mix boulders
Type of landslide	Not chronic
Possible problem identification	High building load on slope, water ingress in slope during rains
Probable remedial measures	Anchors, Bioengineering, retaining structures to arrest slope movement. Building condition survey (BCS) for nearby affected structures. Provision of drainage holes, drainage paths, culverts etc.

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring

- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 14, 00,000/-+ taxes as applicable (18%)

Annexure B.2

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Lana Rauna site, Neri Nawan Panchayat, Pachhad Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Lana Rauna in Neri Nawan panchayat, Pachhad subdivision, Sirmaur district, Himachal Pradesh. The site is unstable on both hill and valley side. On the hill side, the height is 100 m and on the valley side, the depth is 400 m. Length of slide zone is around 800 m.

Observations at the site:

As per officials and locals, this is a massive and chronic landslide occurring for last 20-25 years. The strata consist of highly disintegrated rock mass type along with major presence of fine material. Creep failure has been observed at site and substantial moisture presence is indicated at many places indicating obstructed drainage paths. The slide blocks a major district road on which 35-40 families depend on livelihood and also connects to 500-year-old Jwala mata mandir. On the hill side, failure is of planar type with significant rock slide & rock fall potential. On the valley side, as per officials & locals, during rains, Giri river overflows and may cut the toe of slide causing further instability. Figures 1-6 show photos taken during the visit at the existing site location. The CSIR-CBRI team informed the officials about the necessity of drainage, slope stabilization measures, building condition surveys, river training works and about effectiveness of rock fall barriers



Fig. 1 Highly disintegrated rock mass and fines material



Fig. 2 Significant rock fall potential on hill side slope



Fig. 3 Moisture present in strata indicating blocked drainage paths



Fig. 4 Slide obstructing major district road



Fig. 5 Giri river cutting the toe of slide



Fig. 6 Instability on valley side affecting infrastructure

Conclusions based on site observations

The visited site contains, chronic unstable slope on both hill and valley side with low strength characteristics. Providing drainage holes in this slope, catch drains and drainage paths is of utmost importance to increase stability. Drained water should be properly collected and taken down the hill using culverts into the river to ensure site stability. To arrest toe cutting by Giri river, river training works are required and valley side slope may require retaining structures like gabions. On the hill side, apart from scaling; grouted rock anchors, wire-mesh, shotcreting and bioengineering measures shall need to be adopted. After systematically estimating rock fall hazard, rock fall barrier may also need to be installed. Further Building Condition Survey (BCS survey) may be done to assess the structural health of already affected buildings near the slide. Buildings near fringes of the landslip may be further protected by use of retaining structures and slope stabilization measures etc. on the valley side. The slide may be kept under continuous monitoring & relocation and emergency evacuation plans may be kept ready. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Lana Rauna site, Neri Nawan panchayat, Pachhad subdivision

Slope characteristics (Geometry,Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slope around 100 m high on hill side and 400 m on valley side. ○ Width of site is approximately 800 m ○ Steep slope between 60° to 75° on both hill and valley sides
Location coordinates	30°48'02.9"N, 77°15'36.2"E
Slope material characteristics	Highly disintegrated rock mass and major presence of fines materials
Type of landslide	Chronic from last 25-30 years
Possible problem identification	Low shear strength of strata, Water ingress in slope during rains and inadequate drainage, Toe cutting by Giri river during rains
Probable remedial measures	Anchors, grouting Bioengineering, Geosynthetic retaining structures (GRS) to arrest slope movement. Rock fall barriers for rock fall protection. Building condition survey (BCS) for nearby affected structures. Provision of drainage holes, drainage paths, culverts etc. River training works on valley side. Continuous monitoring & relocation and emergency evacuation plans

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be Six (6) months.

Project Cost

The charges for the above assignment will be Rs. 58, 00,000/-+ taxes as applicable (18%)

Annexure B.3

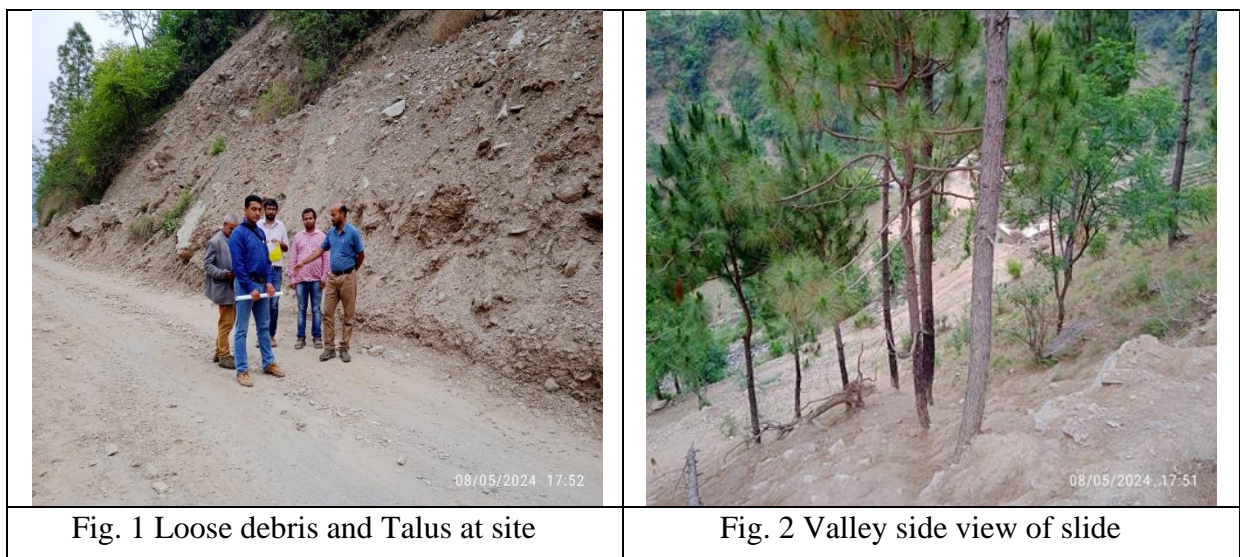
Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Chunnar site, Neri Nawan Panchayat, Pachhad Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Chunnar in Neri Nawan panchayat, Pachhad subdivision, Sirmaur district, Himachal Pradesh. The visited site is unstable on both hill and valley side. On the hill side, the height of slide is estimated to be approximately 800-1000 m and on the valley side, the road level is observed to be only at 5-10 m from the then river level. Length of slide zone is around 1500 m.

Observations at the site:

This is a massive landslide that started small but became major in last 5-6 years only. On the hill side loose debris and Talus were observed & highly disintegrated rock mass with major presence of fines materials was also noticed at some places. Due to road level being very close to river, probability for toe cutting by Giri river is very high. As per local officials around 8-10 houses are present on the hill side directly affected by the slide. This massive slide requires detailed investigation and analysis to provide the mitigation measures. Figures 1-2 show photos taken during the visit at the existing site location. The CSIR-CBRI team informed the officials about the necessity of drainage, slope stabilization measures, building condition surveys, river training works and about effectiveness of rock fall barriers



Conclusions based on site observations

Massive landslide caused by unstable slope on hill side. Toe cutting potential on valley side due to river level being very close to road level. Drainage holes in this slope, catch drains along road and drainage paths can increase the stability of slope. Drained water should be properly collected and taken down the hill using culverts into the river to ensure site stability. To arrest toe cutting by Giri river, river training works are required and valley side slope shall require retaining structures like gabions/ reinforce earth walls or retaining walls. On the hill side, apart from scaling; grouted rock anchors, wire mesh, shotcreting and bioengineering measures shall need to be adopted. Further Building Condition Survey (BCS survey) may be done to assess the structural health of already affected buildings near the slide. The slide may be kept under continuous monitoring & relocation and emergency evacuation plans may be kept ready. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Chunnar site, Neri Nawan panchayat, Pachhad subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slope around 1000 m high on hill side and 5-10 m on valley side. ○ Width of site is approximately 1500 m
Location coordinates	30°46'31.6"N, 77°17'48.3"E
Slope material characteristics	Debris & Talus on hill side, Highly disintegrated rock mass and major presence of fines materials
Type of landslide	chronic, from last 5-10 years
Possible problem identification	Low shear strength of strata, Water ingress in slope during rains and inadequate drainage, Toe cutting by Giri river during rains
Probable remedial measures	Anchors, grouting Bioengineering, retaining structures to arrest slope movement. Rock fall barriers for rock fall protection. Building condition survey (BCS) for nearby affected structures. Provision of drainage holes, drainage paths, culverts etc. River training works on valley side. Continuous monitoring of slope & relocation and emergency evacuation plans

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be Six (6) months.

Project Cost

The charges for the above assignment will be Rs. 58, 00,000/-+ taxes as applicable (18%)

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision (Chainage km 14+165)

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Katchi Dhang NH 707 (Chainage km 14+165) in Muglawala Kartarpur panchayat, Village Sirmauri Tal, Paonta Sahib subdivision, Sirmaur district, Himachal Pradesh. The site has a history of cloudburst where 5 fatalities had happened and many houses were damaged. Height on the hill side is around 30 m and that on valley side is varying from 70-80 m whereas length of disturbed portion is around 300 m. Slope on hill side are observed to be moderately steep with angles varying from 60-75 degrees.

Observations at the site:

This site was observed to be located right beside the national highway NH 707. Highly jointed and sheared rock mass have been observed at site overlain by soil mix with boulder at some locations. On the valley side, still 2 -3 residential structures were observed. It was observed that mitigation work on valley side slope was under progress (construction of retaining wall, drainage culvert etc.). On the hill side slope, on some stretch, retaining stone masonry structure along with coir mat was noticed to encourage vegetation. Considering loose boulders and jointed rock mass on the hill side slope there is potential for rock fall and debris flow during monsoons. Toe of slide on the valley side may also require retaining structure

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.

<p>Fig. 1 Mitigation works on hill side steep slope</p>	<p>Fig. 2 Jointed rock mass and potential for debris flow</p>
<p>Fig. 3 Highly sheared rock mass on the valley side slope</p>	<p>Fig. 4 Residential structures near valley side slope with river in background</p>

Conclusions based on site observations

The site is critical but some mitigation work is also going on at site both on the hill side and the valley side. On the hill side, the support system can be a combination of rock net, self-drilling anchors and bioengineering. Drainage holes may be provided in the slope along with drainage paths and culverts. Further continuous masonry fascia wall is desirable on site. Considering debris flow hazard, fencing may be provided near the outfall on the hill side. On the valley side material seems loose and may need to be scaled. Further rock nets and bioengineering along with retaining structure can prove to be effective in increasing stability of valley side slope. Considering that the valley side habitations observed lie directly in path of land slide or debris flow, emergency evacuation and rehabilitation may be thought of. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision (Chainage km 14+165)

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slope around 30 m on hill side and 70-80 m on valley side. ○ Width of site is approximately 300 m ○ Moderately Steep slope between 60° to 75°
Location coordinates	30°32'42.1"N, 77°38'45.2"E
Slope material characteristics	Jointed rock mass overlain by soil mix boulder (mostly on hill side), highly sheared rock mass on valley side
Type of landslide	Not chronic
Possible problem identification	Presence of loosened rock joints and debris on hill side slope, water ingress in slope during rains, Toe instability on valley side
Probable remedial measures	Rock nets, Self-drilling anchors (SDA's), Bioengineering, masonry retaining structures to arrest slope movement. Debris fencing near outfall. Provision of drainage holes, drainage paths, culverts etc along the slide

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring

- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 33, 00,000/-+ taxes as applicable (18%)

Annexure C.2

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision





Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Katchi Dhang NH 707 in Muglawala Kartarpur panchayat, Village Sirmauri Tal, Paonta Sahib subdivision, Sirmaur district, Himachal Pradesh. Height on the hill side is around 50 m and that on valley side is around 30 m whereas length of disturbed portion is around 450 m. Slope on hill side are observed to be quite steep with angles around 80 degrees. On the valley side slope is moderately steep with angle varying between 70-80 degrees.

Observations at the site:

This site was observed to be located right beside the national highway NH 707. Rock type on hill side varies from very blocky to highly disintegrated with intermittent visible shear bands. On the valley side, mostly debris material is observed. This highly disintegrated low shear strength material along with steep slopes causes the site to be unstable. Further, considering the highly disintegrated rock mass & debris, high potential for debris flow and rock fall is noticed. Considering that river flows quite close to the toe, instability arising out of toe cutting is a distinct possibility that shall render the slope even more prone to future slides. No mitigation measures have been observed on the affected stretch.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.

	
<p>Fig. 1 Very blocky to highly sheared & disintegrated rock mass on hill side</p>	<p>Fig. 2 Hill & valley side instabilities & possibility of debris flow</p>
	
<p>Fig. 3 Toe cutting by river at base of landslide</p>	<p>Fig. 4 High rock fall potential at site</p>

Conclusions based on site observations

The site is critical and presents a large instability on both hill and valley side slopes. On the hill side slope rock net and Self drilling anchors (SDA) may be proposed to arrest slope movement. In order to prevent debris flow, scaling may be employed to clear slope of any large and hazardous boulders or rocks. A 2-2.5 m width toe wall on the hill slide of slope shall provide confinement to the slope. Drainage holes may be provided in the slope along with drainage paths and culverts. These drainage holes empty into lined catch drains which meet at collection point to reach a culvert and which then disposes water into nearby water body. Retaining structures and bioengineering shall be required to confine the valley side slope and river training works required to prevent toe erosion. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Katchi Dhang NH-707 site, Muglawala Kartarpur Panchayat, Village Sirmauri Tal, Paonta Sahib Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slope around 50 m on hill side and 30 m on valley side. ○ Width of site is approximately 450 m ○ Moderate to quite Steep slope between 70° to 80°
Location coordinates	30°32'55.0"N, 77°38'19.3"E
Slope material characteristics	Very blocky to highly disintegrated rock mass (mostly on hill side), Debris material on valley side
Possible problem identification	Presence of highly sheared & disintegrated rock mass and debris on the slope, water ingress in slope during rains, Toe instability on valley side slope caused by river erosion
Probable remedial measures	Rock nets, Self-drilling anchors (SDA's), Bioengineering, masonry retaining structures to arrest slope movement. Provision of drainage holes, drainage paths, culverts etc along the slide. Provision of river training works for valley side slope

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies

- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 36, 00,000/-+ taxes as applicable (18%)

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Khatwar site, Banor Panchayat, Paonta Sahib Subdivision





Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Khatwar in Banor panchayat, Paonta Sahib subdivision, Sirmaur district, Himachal Pradesh. The height of the slide is around 600-700 m whereas length of disturbed portion is around 500 m. The slope was observed to be moderate to quite steep with angle varying between 70-80 degrees.

Observations at the site:

Numerous habitations and agricultural land were found to be present at top of the slide. The slide is unstable and continuous movement has been happening as per locals and officials. Nearby residences and infrastructure have developed large cracks demonstrating slope failure. Slope strata is observed to be composed of debris material, boulders and highly disintegrated rock mass. Continual erosion of land from slide top is leading to progression of landslide towards the village and loss of agricultural land. Large volume of debris moving down during slide can cause damming of the water stream below leading to toe instability for the slope and flooding hazard downstream. No mitigation or prevention measures have been observed to be installed on the affected stretch.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.

	
<p>Fig. 1 Agricultural land under duress at top of slide</p>	<p>Fig. 2 Cracks in infrastructure indicating continuing ground movement</p>
	
<p>Fig. 3 Stream at toe of slide prone to damming and toe cutting</p>	<p>Fig. 4 Strata consisting of debris material and highly disintegrated rock mass</p>

Conclusions based on site observations

The site presents a massive landslide progressing towards residential infrastructure, eroding agricultural lands, cracks in buildings due to ground undergoing continual movement. Presence of agricultural land may increase probability of failure since crop watering may increase moisture content in strata. Building pressure combined with improper drainage from existing houses at slide top may also contribute to instability. Drainage holes, lined drains, culverts and other drainage measures may be employed to slow down the slide and increase ground stability. Considering movement and massive dimension of slide, regular monitoring of this slide (and debris movement into the stream below) is necessary & emergency evacuation and rehabilitation plans for habitants may be considered. Relocation of inhabitants from this site may also be considered. Table 1 presents the summary of observations made

during the visit at the selected location.

Table 1: Summary of observed landslide site at Khatwar site, Banor Panchayat, Paonta Sahib Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slide around 600-700 m. ○ Width of site is approximately 500 m ○ Moderate to quite Steep slope between 70° to 80°
Location coordinates	30°35'54.6"N, 77°43'35.2"E
Slope material characteristics	Debris materials, highly disintegrated rock mass and boulders
Possible problem identification	Presence of highly sheared & disintegrated rock mass and debris on the slope, water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings and crop watering of agricultural land
Probable remedial measures	Regular monitoring & emergency evacuation and rehabilitation plans. Relocation of inhabitants may be considered.

Scope of work: Considering criticality of site, relocation of inhabitants may be considered.

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Malgaon site, Nehli Dheeda Panchayat, Nahan Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Malgaon in Nehli Dheeda panchayat, Nahan subdivision, Sirmaur district, Himachal Pradesh. The height of the slide on the hill side is around 50 m, valley side disturbance extends to around 50 m height; whereas length of disturbed portion is around 50 m. The slope was observed to be moderately steep with angle varying between 50-70 degrees.

Observations at the site:

Village road was observed to be passing through the disturbed area and 3-4 houses were observed on the valley side affected by the ground movement. Ongoing construction work for slope mitigation was also observed at site. Ground strata primarily consisted of fine soil and debris mix with boulders also observed at many places. Presence of ground cracks was observed at some places. Considering the presence of loose fine soil along with debris, water ingress during rains may lead to movement.

Figures 1-2 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 Fine soil and debris material visible in strata	Fig. 2 Crack formation indicating ground movement
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Conclusions based on site observations

Considering strata and slope, retaining wall may be provided along the road for stabilization. Both hill and valley side slopes may be stabilized by netting, self-drilling anchors and bioengineering measures. Additionally, removal of boulders may be done to address rock fall potential. Drainage holes, lined drains, culverts and other drainage measures may be employed to slow down the slide and increase ground stability. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Malgaon site, Nehli Dheeda Panchayat, Nahan Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slide around 50 m on hill side and 50 m on valley side ○ Width of site is approximately 50 m ○ Moderate Steep slope between 50° to 70°
Location coordinates	30°36'52.7"N, 77°22'04.3"E
Slope material characteristics	Fine soil with Debris materials, boulders
Possible problem identification	Water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Retaining structures, netting, bioengineering etc.

Scope of work: PWD is already working on stabilization of this site

Annexure D.2

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Jarag site, Nahan Subdivision

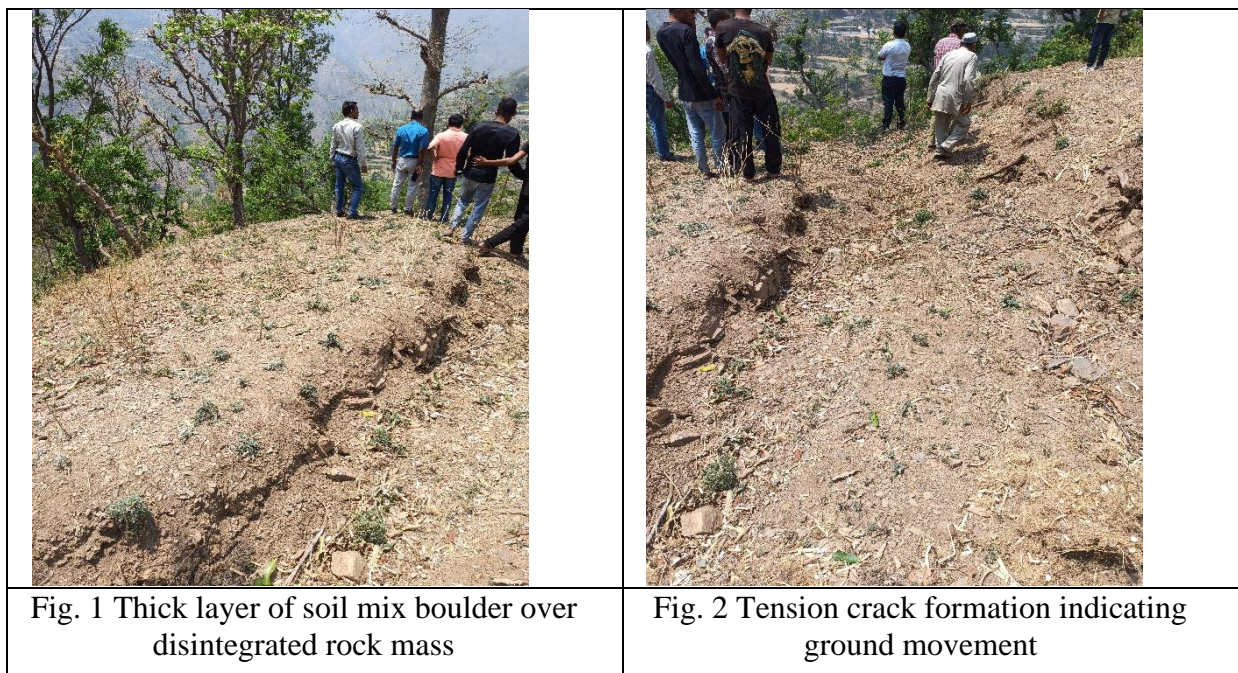
Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Jarag, Nahan subdivision, Sirmaur district, Himachal Pradesh. On the valley side, disturbance extends to around 1500 m height; whereas length of disturbed portion is around 2000 to 2500 m. The slope was observed to be steep with angle varying between 60-80 degrees.

Observations at the site:

It was informed by local and district officials that this landslide is not chronic and has become activated since last year only causing massive ground movement. Ground strata primarily consisted of highly disintegrated rock mass overlain by a thick layer of soil mix boulder matrix. Tension cracks were prominently visible at site that can lead to water ingress in slope during rains and further destabilize the slope. It was informed that around 20-25 houses are present at the top and a couple of houses on the valley side of slide which had suffered damage. River flowing near toe of the slide has potential to cut the slope causing further instability

Figures 1-2 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Conclusions based on site observations

Considering the unstable, massive landslide characteristics which posing threats to the inhabitants, proper ground investigation is necessary Before installation of mitigation

measures, geophysical survey may be conducted to estimate the depth of overburden over the rock mass. River training works shall protect the toe slope and prevent further instability. Piles can be installed at the terrace to prevent ground movement and increase stability. Self-drilling anchors and bioengineering can further stabilize the slope. Drainage holes, lined drains, culverts and other drainage measures may be employed to slow down the slide and increase ground stability. Waste water percolation in the ground and crop watering can adversely affect slope stability. Building condition survey (BCS) can help in determining the structural integrity of the houses. Monitoring of slide is necessary and emergency evacuation and rehabilitation plans may be required. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Jarog site, Nahan Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slide around 1500 m on valley side ○ Width of site is approximately 2000-2500 m ○ Steep slope between 60° to 80°
Location coordinates	30°38'09.9"N , 77°28'03.0"E
Slope material characteristics	Highly disintegrated rock mass overlain by a thick layer of soil mix boulder matrix
Type of landslide	Not chronic
Possible problem identification	Water ingress in slope during rains, building loads on slope, Improper drainage of existing buildings & crop watering on slope, Toe cutting by river
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. River training works at toe, piling near terrace, Self-drilling anchors, retaining structures, bioengineering etc. Building condition survey (BCS) for existing infrastructure, Regular monitoring of slope, emergency evacuation and rehabilitation plans

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be Six (6) months.

Project Cost

The charges for the above assignment will be Rs. 58, 00,000/-+ taxes as applicable (18%)

Annexure D.3

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Agdiwala site, Mattar panchayat, Nahan Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Agdiwala, Mattar panchayat, Nahan subdivision, Sirmour district, Himachal Pradesh. Multiple locations susceptible to landslides have been informed by the locals and district officials. In general, for location one ground movement was observed along long stretch of land (around 1000-2000 m) with average slope heights of around 100 m on hill and valley sides. For the second location, the length of disturbed portion varies from 150 to 250 m, height from 30-50 m (for both hill and valley side instability) and moderately steep slope angle of 60 degrees.

Observations at the site:

On the first location, soil was observed to consist of low plasticity clay and silt. The site was primarily affecting agricultural land but not many residential buildings. Long length tension

cracks were also present at the site indicating substantial ground movement. These can provide avenue for water ingress during rains and make slope more critical. Crop water for agriculture also keeps the moisture content in the slope high.

Strata at second location was almost similar but silty sandy silt was also noticed at some locations. This area was habituated with around 6-7 houses and these were primarily affected by ground movement due to unstable slopes

Low shear strength material combined with already present moisture in soil makes this site susceptible to ground movement and it may become more severe during rains. It was informed by local and district officials that these slides are not chronic and have become activated since last year only causing massive ground movement.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.

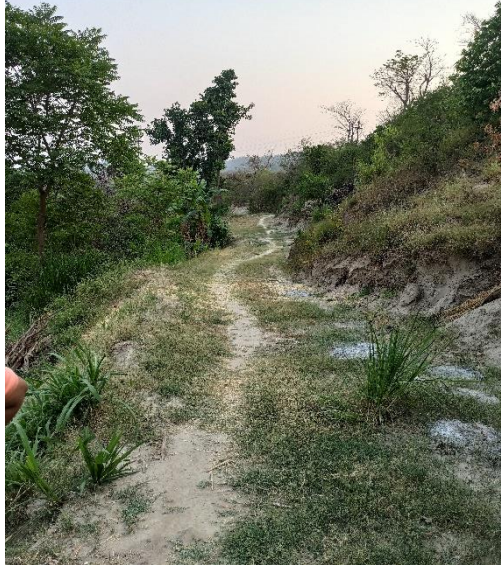

	
Fig. 1 Low plasticity clay, silt and sand at site (location 2)	Fig. 2 Agricultural land near site (location 1)



Fig. 3 Residential habitation near site (location 2)



Fig. 4 Building load on site (location 2)

Conclusions based on site observations

Considering the type of unstable strata, drainage holes, lined drains, culverts and other drainage measures may be employed to slow down the slide and increase ground stability. Proper arrangements for disposal of building wastewater should be made so that it does not percolate into the slope. Also building condition survey (BCS) may be done to assess the structural integrity of the buildings in the slide zone. Further bioengineering, wire mesh, self-drilling anchors and retaining structures can primarily be used on site to confine the slope and arrest ground movement. Regular monitoring of the slope is necessary & emergency evacuation and rehabilitation plan may be considered. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Agdiwala site, Mattar panchayat, Nahan Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of slide around 100 m, Length of site is approximately 1000-2000 m at location 1 ○ Height of slide around 30-50 m, Length of site is approximately 150-250 m at location 2 ○ Moderately Steep slope between 60° to 80°
Location coordinates	30°28'11.9"N, 77°22'56.9"E (Location 1) and 30°28'09.3"N, 77°22'45.4"E (Location 2)
Slope material characteristics	Low plasticity clay and silt, sand

Type of landslide	Not chronic
Possible problem identification	Water ingress in slope during rains, Building loads on slope, Improper drainage of existing buildings & crop watering on slope
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, retaining structures, bioengineering etc. Building condition survey (BCS) for existing infrastructure, Regular monitoring of slope, emergency evacuation and rehabilitation plans

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 36, 00,000/-+ taxes as applicable (18%)

Annexure D.4

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Tirmali Dyar site, Birla panchayat, Nahan Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Tirmali Dyar, Birla panchayat, Nahan subdivision, Sirmaur district, Himachal Pradesh. The depth of valley slope varies from 15-20 m and hill slope height is around 100 m. The length of affected zone is around 300 m and slope is moderately steep at around 60 degrees.

Observations at the site:

Ground strata consisted of debris material and soil mix with boulder. The slide is affecting

the major district road and 2-3 multistoried buildings on the hill side. This heavy building loads may lead to further instability of the slope. In addition to fines with debris material, boulders are also present on the site and may lead to rock fall. Valley side instability has led to erosion of the road and its settlement affecting traffic flow. Presence of river near toe slope can have detrimental effect on slope when water level in river is high. It was informed by local officials that this slide is not chronic.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 Major district road and multistoried buildings



Fig. 2 Toe cutting by river below the slide



Fig. 3 Fine soil and debris material and erosion of road



Fig. 4 Rock fall potential at site

Conclusions based on site observations

Perforated drainage holes, lined drains, culverts and other drainage measures may be employed to slow down the slide and increase ground stability. Proper arrangements for disposal of building wastewater should be made so that it does not percolate into the slope. Mechanically stabilized reinforced (MSE) wall may be employed for stabilizing the road and retaining wall to prevent hill side slope movement. Also building condition survey (BCS) may be done to assess the structural integrity of the buildings in the slide zone. Further bioengineering, wire mesh & rock net, self-drilling anchors and retaining structures can primarily be used on site to confine the slope and arrest ground movement. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Tirmali Dyar site, Birla panchayat, Nahan Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of valley side slope around 15-20 m, height of hill side slope around 100 m. Length of site is approximately 300 m. ○ Moderately Steep slope of 60°
Location coordinates	30°35'15.8"N, 77°26'41.7"E
Slope material characteristics	Fines with debris material, boulders
Type of landslide	Not chronic
Possible problem identification	Water ingress in slope during rains, building loads on slope, Improper drainage of existing buildings & toe cutting by river

Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, rock net Reinforced earth & Retaining structures, bioengineering etc. Building condition survey (BCS) for existing infrastructure,
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Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 33, 00,000/-+ taxes as applicable (18%)

Annexure E.1

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Shallana site, Rajgarh Subdivision

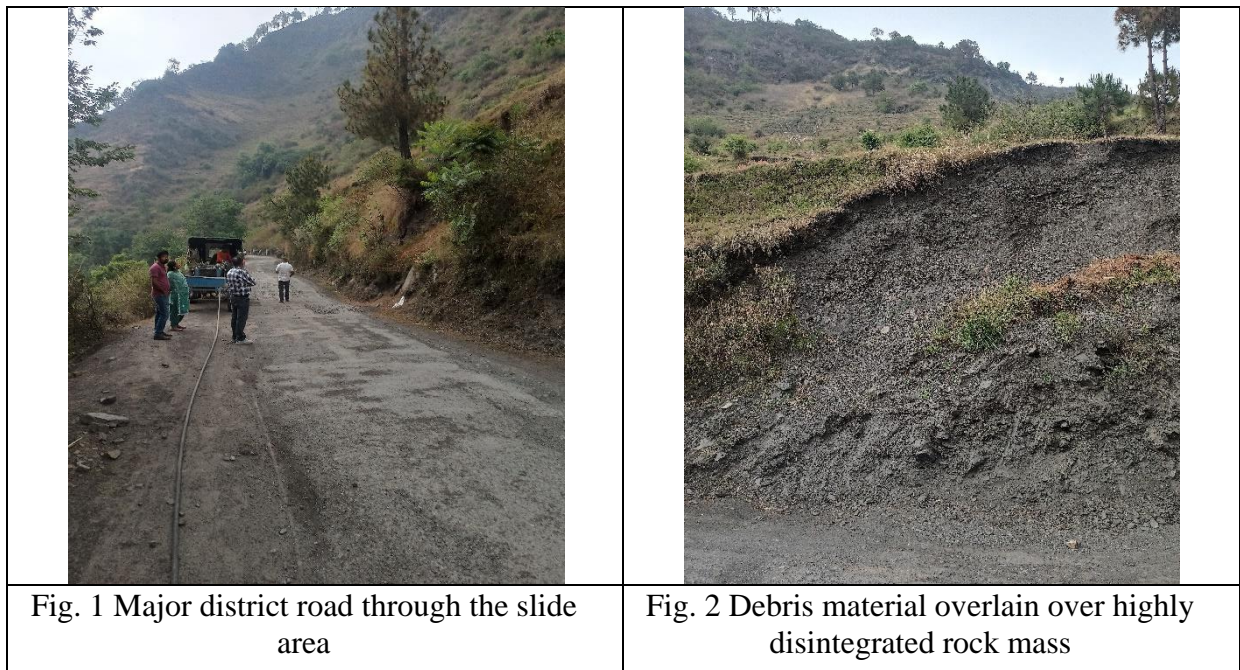
Introduction:

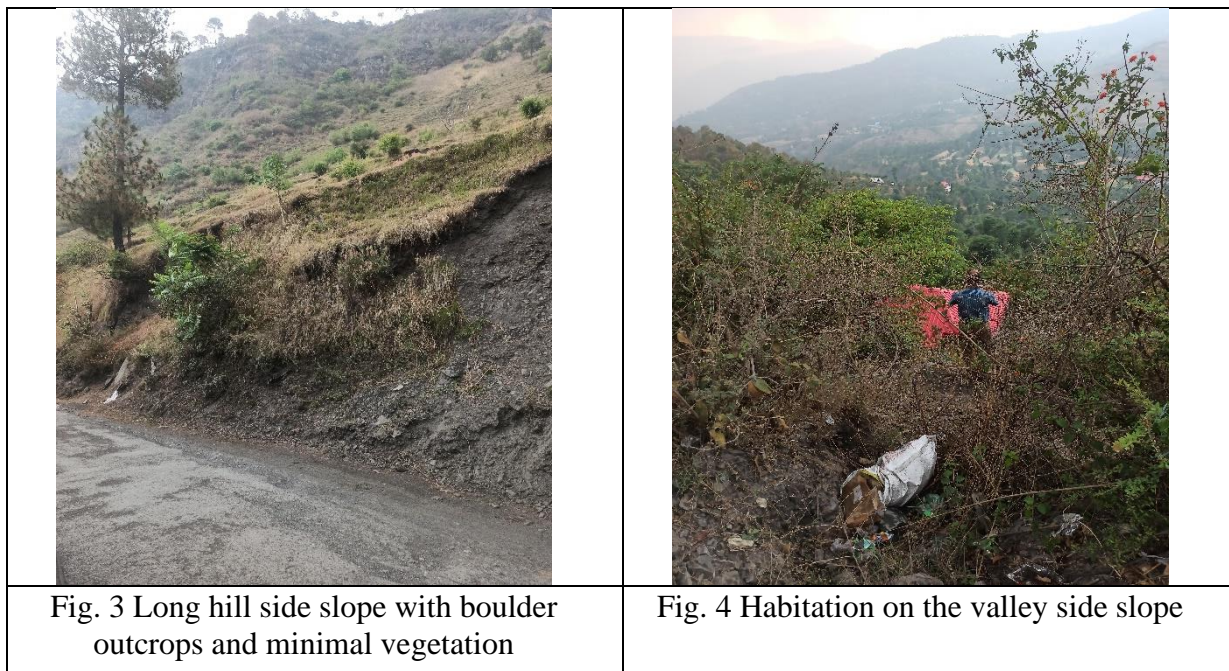
The team from CSIR CBRI along with district administration officials visited landslide site Shallana, Rajgarh subdivision, Sirmaur district, Himachal Pradesh. The height of hill slope is around 700-1000 m & valley slope is around 200-300 m. The length of affected zone is around 200 m and slope is moderately steep at around 60 degrees on both hill and valley side.

Observations at the site:

Ground strata consisted of thick debris material and soil mix with boulder overlain over highly disintegrated rock mass. The slide is affecting the major district road and 2-3 buildings near the slide area. Due to long slope on the hill side, in addition to debris material, boulders are also present on the site and may lead to rock fall and debris flow. Slide on the valley side of slope can lead to settlement of road and affect the traffic on major district road.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.





Conclusions based on site observations

Perforated drainage holes, lined drains, culverts and other drainage measures may be employed to slow down the slide and increase ground stability. Further bioengineering, wire mesh & rock net, self-drilling anchors and retaining structures can primarily be used on site to confine the slope and arrest ground movement. Debris flow barrier and rock fall barrier may also be required on the hill side slope. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Shallana site, Rajgarh Subdivision

<p>Slope characteristics (Geometry, Length, width, average slope angle etc.)</p>	<ul style="list-style-type: none"> ○ Height of valley side slope around 200-300 m , height of hill side slope around 700-1000 m. Length of site is approximately 200 m. ○ Moderately Steep slope of 60°
<p>Location coordinates</p>	<p>30°50'16.4"N, 77°17'50.1"E</p>
<p>Slope material characteristics</p>	<p>Debris material and soil mix with boulder overlain over highly disintegrated rock mass.</p>
<p>Possible problem identification</p>	<p>Water ingress in slope during rains, Low shear strength of strata, Boulder outcrops and long slope without much vegetation</p>
<p>Probable remedial measures</p>	<p>Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, rock net &</p>

	Retaining structures, bioengineering etc. Debris flow barrier and rock fall barrier
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Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be five (5) months.

Project Cost

The charges for the above assignment will be Rs. 46, 00,000/-+ taxes as applicable (18%)

Annexure E.2

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Shalech Kanchi site, Kotla Bangi Panchayat, Rajgarh Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Shalech Kanchi, Kotla Bangi panchayat, Rajgarh subdivision, Sirmaur district, Himachal Pradesh. The height of hill slope is around 70-80 m & valley slope is around 70-80 m. The length of affected zone is around 150 m and slope is moderately steep at around 60-70 degrees on both hill and valley side.

Observations at the site:

Ground strata consisted of predominantly fine soil mixed with debris material underlain by

blocky rock mass. A retaining wall is already under construction on the valley side by PWD. A state highway passes through the slide zone and a primary school is also existing down on the valley side. As per locals and officials, this slide is not chronic and has been activated since last year only. Tree movement on the valley side indicates substantial ground movement on the valley side slope. High overburden along the slope shall make the slope unstable particularly during rains. Slide on the valley side of slope can lead to settlement of road and affect the traffic on the state highway. Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 Fine soil with debris material underlain by blocky rock mass



Fig. 2 Habitation and school present on the valley side



Fig. 3 State highway passing through slide zone & tree tilting indicating ground movement



Fig. 4 Large debris overburden and minimum vegetation on hill side slope

Conclusions based on site observations

Perforated drainage holes, lined drains, culverts and other drainage measures may be employed to slow down the slide and increase ground stability. Further bioengineering, wire mesh & rock net, self-drilling anchors and retaining structures can primarily be used on site to confine the slope and arrest ground movement. Debris flow barrier and rock fall barrier may also be required on the hill side slope. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Shalech Kanchi site, Kotla Bangi Panchayat, Rajgarh Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of valley side slope around 70-80 m , height of hill side slope around 70-80 m. Length of site is approximately 150 m. ○ Moderately Steep slope angle varying between 60 - 70°
Location coordinates	30°57'18.5"N, 77°19'36.2"E
Slope material characteristics	Predominantly fine soil mixed with debris material underlain by blocky rock mass
Type of landslide	Recent
Possible problem identification	Water ingress in slope during rains, Low shear strength of strata, Boulder outcrops and long slope

	without much vegetation
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Self-drilling anchors, rock net & Retaining structures, bioengineering etc. Debris flow barrier and rock fall barrier

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 33, 00,000/-+ taxes as applicable (18%)

Annexure E.3

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Near Kot site, Kothia Jajar Panchayat, Kot Dhanger village Rajgarh Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Near Kot, Kothia Jajar panchayat, Kot Dhanger village, Rajgarh subdivision, Sirmaur district, Himachal Pradesh. The height of hill slope is around 70-80 m & valley slope is around 70-80 m. The length of affected zone is around 150 m and slope is moderately steep at around 60-70 degrees on both hill and valley side.

Observations at the site:

Ground strata consisted of predominantly very blocky rock mass. Major sliding is not observed on site but major water seepage problem is detected. Figures 1 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 Major water seepage at site

Conclusions based on site observations

Perforated drainage holes, lined drains, culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. Further hydrological mapping of the site may be required to get water source and drainage flow of water on the slope. No major sliding observed from slide apart from water seepage problem. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Near Kot site, Kothia Jajar Panchayat, Kot Dhanger village Rajgarh Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none">○ Height of valley side slope around 70-80 m , height of hill side slope around 70-80 m. Length of site is approximately 150 m.○ Moderately Steep slope angle varying between 60 - 70°○ Major water seepage at site
Location coordinates	30.817351586382557, 77.27604066776871
Slope material characteristics	Very blocky rock mass
Possible problem identification	Water drainage problem at site and major water seepage at site

Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Hydrological mapping for water source
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Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 36, 00,000/-+ taxes as applicable (18%)

Annexure E.4

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Khairi Dhank site, Dimber Panchayat, Rajgarh Subdivision

Introduction:

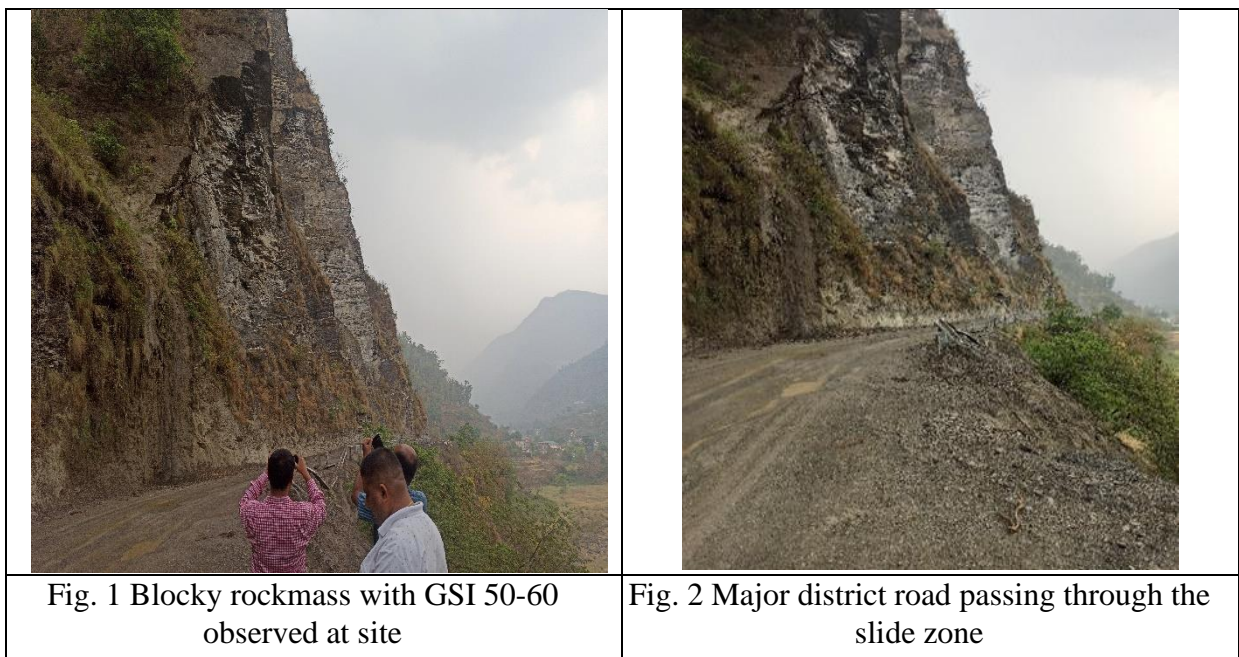
The team from CSIR CBRI along with district administration officials visited landslide site Khairi Dhank, Dimber panchayat, Rajgarh subdivision, Sirmaur district, Himachal Pradesh. The height of hill slope is around 200 m & valley slope is around 1000 m. The length of affected zone is around 200 m and slope is quite steep at around 65-80 degrees on both hill and valley side.

Observations at the site:

Ground strata consisted of predominantly very blocky phyllite rock mass with GSI value around 50-60. Due to loosened rock mass, hill side slope shows potential for rock fall. Valley

side slope seems susceptible to slide which may cause the major district road passing through slide zone to be affected. No mitigation measures were observed to be implemented on site. No major habitation were observed to be present near the site. River was observed to be flowing very near to the slide location and toe cutting during rainy season cannot be ruled out.

Figures 1-2 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Conclusions based on site observations

Perforated drainage holes, lined drains, culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. Debris flow fence and rock fall barrier may be required on site to protect against this hazard. To stabilize the slope and prevent the road deformation, Gabion/retaining wall may be required. River training works may be required to protect the toe of slide. Rock bolts and rock nets may have to be installed at site to prevent local as well as global failure. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Khairi Dhank site, Dimber Panchayat, Rajgarh Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of valley side slope around 1000 m, height of hill side slope around 200 m. Length of site is approximately 200 m. ○ Moderately Steep slope angle varying between 60 - 70°
Location coordinates	30°46'52.4"N ,77°17'51.7"E
Slope material characteristics	Very blocky phyllite rock mass
Possible problem identification	Blocky & loose rock mass, Toe cutting at base by river, Water ingress in joints through slopes
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining structures on valley side, river training works at toe of slide. Rock bolts and rock nets on the hill side. Debris fence and rock fall barrier

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation

- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 22, 00,000/-+ taxes as applicable (18%)

Annexure F.1

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Ganali site, Millah Panchayat, Shillai Subdivision

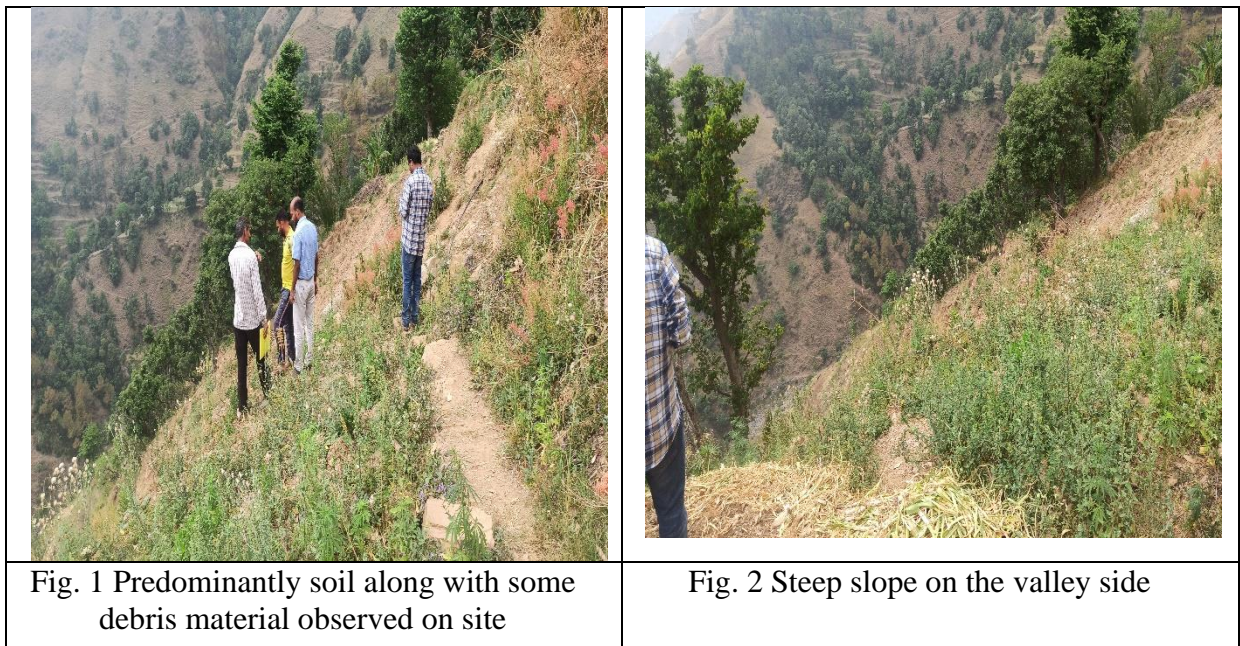
Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Ganali, Millah panchayat, Shillai subdivision, Sirmaur district, Himachal Pradesh. The height of valley slope is around 300 m. The width of affected zone is around 100 m and slope is moderate at around 45-60 degrees.

Observations at the site:

Ground strata consisted of predominantly soil along with some debris material and boulders. Competent rock is not found on site. Due to loosened overburden, valley side slope seems susceptible to slide which may affect 15 -16 houses present near the slide zone as well as the agricultural land. No mitigation measures were observed to be implemented on site. Some

tension cracks were observed at site indicating ground movement. During rainy season, the strata is very susceptible to water ingress and shall increase the probability of failure of slope. Figures 1-2 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Conclusions based on site observations

Perforated drainage holes, lined drains, culverts and other drainage measures may be

employed to reduce probability of any potential slide and increase ground stability. To stabilize the slope and prevent the ground movements, Gabion/retaining structures and monopiles may be required. Considering large dimension of the slide, detailed study of the slide area is required. To determine the structural integrity of affected buildings, building condition survey (BCS) survey is proposed, Regular monitoring of the slope along with emergency evacuation and rehabilitation measures may need to be assessed. Wastewater drainage from nearby habitation should be taken away from slide area and released. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Ganali site, Millah Panchayat, Shillai Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of valley side slope around 300 m. Length of site is approximately 100 m. ○ Moderately Steep slope angle varying between 45 – 60°
Location coordinates	30°41'35.7"N, 77°38'43.1"E
Slope material characteristics	Predominantly soil along with debris material and boulders
Possible problem identification	Loose strata, Water ingress in slopes and tension cracks, building load on slope, improper drainage from houses, crop watering
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. River training works, Gabion/retaining structures on valley side, Monopiles and grouted rock anchors, Building

	condition survey (BCS) of the existing buildings, regular monitoring & emergency evacuation & rehabilitation of the habitants
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Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be Six (6) months.

Project Cost

The charges for the above assignment will be Rs. 58, 00,000/-+ taxes as applicable (18%)

Annexure F.2

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Bindoli site, Ajroli Panchayat, Shillai Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Bindoli, Ajroli panchayat, Shillai subdivision, Sirmaur district, Himachal Pradesh. The height of hill and valley side slopes are around 300 m. The width of affected zone is around 800-1000 m. Hill side slope is slightly steeper with angle ranging from 50-70° compared to valley side slope with inclination between 50 to 60°

Observations at the site:

As per local officials this landslide is chronic and has been active for last 15-20 years. The site becomes more critical since it affects a major district road that passes through it which has been experiencing settlement in recent times. About 15-20 buildings and agricultural land on the hill top side may be affected by the slide and some portions of villages are already

experiencing settlement. Tension cracks have also been observed on the hill side of slope. Slope strata was observed to be consisting of debris material underlain with highly disintegrated rock mass. No mitigation measures were observed to be implemented on site. Minimal on-slope vegetation, presence of loose debris material and small boulders make the slide susceptible to rock fall.

Water flowing near toe of slide may cause toe cutting and further instability of the slope. During rainy season, the slope shall become more susceptible to failure due to water ingress. Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 Major district road passing through slide zone



Fig. 2 Debris material visible on valley side slope along with seasonal stream



Fig. 3 Debris material underlain with highly disintegrated rock mass



Fig. 4 Potential for rock fall and debris flow at site

Conclusions based on site observations

Perforated drainage holes, lined stepped down drains (preferably with geosynthetic), culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. On the hill side slope, self-drilling anchors and rock mass netting may be required along with bioengineering and wire mesh. Retaining/Gabion/MSE wall may be used to maintain stability of road from alley side. River training works near toe of slide and bioengineering measures can further stabilize the valley side slope. Considering large dimension of the slide, detailed study of the slide area is required. To prevent debris flow and rock fall barriers may be required at some places. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Bindoli site, Ajroli Panchayat, Shillai Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of hill and valley side slope around 300 m. Length of site is approximately 800-1000 m. ○ Moderately Steep slope angle varying between 50 – 70°
Location coordinates	30°46'23.7"N, 77°38'15.7"E
Slope material characteristics	Debris material underlain with highly disintegrated rock mass
Type of landslide	Not Chronic
Possible problem identification	Loose strata, Water ingress in slopes and tension cracks, Toe cutting by water stream, Boulder outcrops and debris on slope having minimal vegetation
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structures on valley side, Self-drilling anchors, rock net and wire mesh on hill side. River training works near toe of slope and bioengineering. Debris flow and rock fall barrier

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring

- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be five (5) months.

Project Cost

The charges for the above assignment will be Rs. 46, 00,000/-+ taxes as applicable (18%)

Annexure G.1**Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Ungarkando site, Rajana Panchayat, Sangrah Subdivision****Introduction:**

The team from CSIR CBRI along with district administration officials visited landslide site Ungarkando, Rajana panchayat, Sangrah subdivision, Sirmaur district, Himachal Pradesh. This site comprises of two locations. Location 1 is minor slide with length of disturbance up to 200 m, height of hill being 100 m, that on valley side being around 700 m. Slope at location 1 is moderately steep with angle between 40 -50° . Location 2 is a massive slide where the height of hill slope is around 300 m. The width of affected zone is around 200-250 m and the depth of valley side slope is 50 m. Slopes at Location 2 are quite steep with angle around 70°.

Observations at the site:

For location 1, the slide zone encompasses a state highway where movement is affected whenever slide happens. Debris material was observed on the slope.

Location 2 indicates massive failure of slope with presence of thick layer of debris material and disintegrated rock mass at different locations. Presence of free thick layer of debris on the slope and boulder outcrops indicate the potential for rock fall and shooting stones. Massive hill cutting was observed at site due to landslide with visible overburden. This has further weakened the slope and more slides may happen with increase in moisture content of strata during rains. Further at some stretches, instability of valley side is observed leading to settlement and displacement of the passing state highway. Detailed investigation of this slide is necessary for smooth movement on this state highway. No mitigation measures were observed to be implemented on site. Water flowing near toe of slide may cause toe cutting and further instability of the slope. During rainy season, the slope shall become more susceptible to failure due to water ingress.

Figures 1-2 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Conclusions based on site observations

Perforated drainage holes, lined stepped down drains (preferably with geosynthetic), culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. For location 1, on the hill side slope, self-drilling anchors, retaining wall and rock net may be installed. On the valley side river training works and retaining wall structure may be required.

For location 2, scaling is required to remove free debris material and boulders from slope and retaining structure may be required on the valley side. In addition to rock net, Self-drilling anchors and retaining walls on the slopes, bioengineering measures may be required to be installed at site. River training works may be required to protect the toe of slide.

To prevent debris flow and rock fall barriers may be required at some places. Table 1 presents the summary of observations made during the visit at the selected location.

Table 1: Summary of observed landslide site at Ungarkando site, Rajana Panchayat, Sangrah Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of hill and valley side slope around 100 m and 700 m respectively. Length of site is approximately 200 m. (Location 1) ○ Height of hill and valley side slope around 300 m and 50 m respectively. Length of site is approximately 200-250 m. (Location 2) ○ Moderately to quite Steep slope angle varying between 40 – 70°
Location coordinates	30°38'05.8"N, 77°27'47.1"E (Location 1); 30°37'21.1"N, 77°27'45.8"E (Location 2)
Slope material characteristics	Debris material underlain with highly disintegrated rock mass
Possible problem identification	Water ingress in slopes and tension cracks, Toe cutting by water stream, Boulder outcrops and debris on slope
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structures on valley side, Self-drilling anchors, rock net and wire mesh on hill side. River training works near toe of slope and bioengineering. Debris flow and rock fall barrier

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through

numerical/analytical studies

- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be five (5) months.

Project Cost

The charges for the above assignment will be Rs. 46, 00,000/-+ taxes as applicable (18%)

Annexure G.2

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Bounal site, Bounal Kakog Panchayat, Sangrah Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Bounal, Bounal Kakog panchayat, Sangrah subdivision, Sirmaur district, Himachal Pradesh. At the slide location, the height of hill slope is around 70-80 m. The width of affected zone is around 200 m and the depth of valley side slope also ranges from 60-70 m. Slopes at this location is quite steep with angle around 70°.

Observations at the site:

On this landslide location failure of slope with presence of thick layer of debris material and disintegrated rock mass was observed. The slide is affecting a major district road that is passing through it in addition to 3-6 houses and a shop that is near it. Further weakening of

the slope and more slides may happen with increase in moisture content of strata during rains. The instability of valley side is more pronounced leading to settlement and displacement of the passing state highway. Some mitigation measures were being installed on site by PWD. Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.

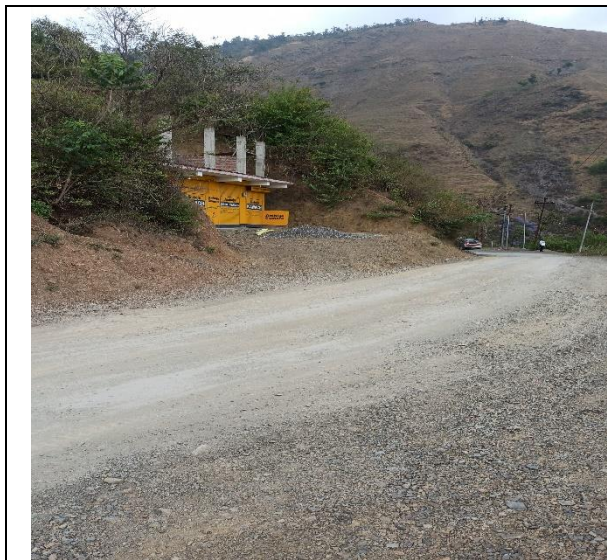


Fig. 1 Infrastructure (road and building) in the slide zone



Fig. 2 Debris material on slope and inclined tower indicating ground movement



Fig. 3 Instability in valley side and erosion of carriageway	Fig. 4 Exposed face on hill side slope and debris overburden
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Conclusions based on site observations

Perforated drainage holes, lined stepped down drains (preferably with geosynthetic), culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. On the hill side slope, self-drilling anchors (SDA's), retaining wall and rock net in addition to bioengineering may be installed. On the valley side also retaining walls/gabion walls/ MSE wall structure may be required for long term stability of road.

Table 1: Summary of observed landslide site at Bounal site, Bounal Kakog Panchayat, Sangrah Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of hill and valley side slope around 70 - 80 m and 60-70 m respectively. Length of site is approximately 200 m. ○ Moderately to quite Steep slope angle varying between 40 – 70°
Location coordinates	30°38'52.0"N, 77°26'26.0"E
Slope material characteristics	Debris material underlain with highly disintegrated rock mass
Possible problem identification	Water ingress in slopes and tension cracks, low shear strength of strata, unstable geometry
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE

	structures on valley side, Self-drilling anchors, netting and bioengineering on hill side.
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Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 36, 00,000/-+ taxes as applicable (18%)

Annexure G.3

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Gatta Mandwach site, Sangrah Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Gatta Mandwach, Sangrah subdivision, Sirmaur district, Himachal Pradesh.

At the slide location, the height of hill slope is around 250 m. The width of affected zone is around 500 m and the depth of valley side slope also ranges from 150-250 m. Slopes at this location is moderately steep with angle around 50-60°.

Observations at the site:

On this slide location, the strata consist of thick layer of debris material and disintegrated rock mass. A district road passes through this slide zone and traffic is affected in case of slide. Slope mitigation work (gabion wall construction) was also being executed on site. The instability extends to both hill and valley side of the road. Further weakening of the slope and more slides may happen with increase in moisture content of strata during rains. In addition to rains, the area also receives snowfall. Presence of loose debris material and boulder outcrops were observed on the site that indicate debris flow and rock fall potential.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 District road passing through the slide zone



Fig. 2 Debris material and loose boulders indicate debris flow and rock fall potential



Fig. 3 Strata consists of debris material underlain by disintegrated rock mass



Fig. 4 Ongoing slope mitigation work

Conclusions based on site observations

Perforated drainage holes, lined stepped down drains (preferably with geosynthetic), culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. Considering loose debris and boulders on the site, scaling, may need to be done. On the hill side slope, self-drilling anchors (SDA's), retaining wall/Gabion and wire mesh in addition to bioengineering may be installed. On the valley side also retaining walls/gabion walls/ MSE wall structure in addition to bioengineering may be required for long term stability of road. Rock fall barrier may be required at site considering the risk of shooting stones.

Table 1: Summary of observed landslide site at Gatta Mandwach site, Sangrah Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none"> ○ Height of hill and valley side slope around 250 m and 150-200 m respectively. Length of site is approximately 500 m. ○ Moderately steep slope angle varying between 50 – 60°
Location coordinates	30°42'42.2"N, 77°35'10.2"E
Slope material characteristics	Debris material underlain with highly disintegrated rock mass
Possible problem identification	Water ingress in slopes and tension cracks, low shear strength of strata, unstable geometry
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structures & bioengineering on valley side, Self-drilling anchors, netting and bioengineering on hill side. Provision for rock fall barrier

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations

- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 33, 00,000/-+ taxes as applicable (18%)

Annexure G.4

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Harlog site, Bhujond panchayat, Sangrah Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Harlog, Bhujond panchayat, Sangrah subdivision, Sirmaur district, Himachal Pradesh.

At the slide location, the height of hill slope is around 150-160 m. The width of affected zone is around 500 m and the depth of valley side slope also ranges from 250 m. Slopes at this location is moderately steep with angle around 50°.

Observations at the site:

On this slide location, the strata consist of thick layer of debris material and disintegrated rock mass. At some places joints in the rock mass on the hill side are observed to be dipping towards the road indicating unstable orientation. In addition to state highway passing through the slide zone, 5-6 houses are also located in the affected zone. No slope mitigation work was seen to be executed on site. The instability extends to both hill and valley side of the road. Further weakening of the slope and more slides may happen with increase in moisture content of strata during rains. Presence of boulder outcrops were observed on the site that indicate rock fall potential.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 State highway passing through the slide zone



Fig. 2 Rock joint dipping towards road indicating instability



Fig. 3 Strata consists of debris material underlain by disintegrated rock mass



Fig. 4 Valley side slope at site

Conclusions based on site observations

Perforated drainage holes, lined stepped down drains (preferably with geosynthetic), culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. Considering loose debris and boulders on the site, scaling, may need to be done. On the hill side slope, self-drilling anchors (SDA's), retaining wall/Gabion and wire mesh may be installed. On the valley side also retaining walls/gabion walls/ MSE wall structure may be required for long term stability of road. Rock fall barrier may be required at site considering the risk of shooting stones.

Table 1: Summary of observed landslide site at Harlog site, Bhujond panchayat, Sangrah Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none">○ Height of hill and valley side slope around 150-160 m and 250 m respectively. Length of site is approximately 500 m.○ Moderately steep slope angle around 50°
Location coordinates	30°44'10.0"N, 77°24'08.0"E
Slope material characteristics	Debris material underlain with highly disintegrated rock mass
Possible problem identification	Water ingress in slopes and tension cracks, low shear strength of strata, unstable geometry
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining/MSE structure on valley side, Self-drilling anchors, netting on hill side. Provision for rock fall barrier

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation

- Evaluation of site-specific parameters for slope stability analysis
- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be five (5) months.

Project Cost

The charges for the above assignment will be Rs. 46, 00,000/-+ taxes as applicable (18%)

Annexure G.5

Site Observations and Project Proposal for Detailed Project Report (DPR) Preparation for Landslide Mitigation on Charna petrol pump site, Sangrah Subdivision

Introduction:

The team from CSIR CBRI along with district administration officials visited landslide site Charna petrol pump, Sangrah subdivision, Sirmaur district, Himachal Pradesh.

At the slide location, height of hill & valley side slope is around 400-500 m. The width of affected zone is around 300 m. Slopes at this location is moderately quite steep with angle around 75 - 85°.

Observations at the site:

On this slide location, the strata consist of highly jointed rock mass while on the valley side a thin layer of debris was observed. The site lies on a major road and suffered from both hill and valley side instability. To bypass this instability, bypass bridge was observed to be under construction on the site. Intense folding of rock mass was observed on site that indicated highly stressed rock mass. In addition to major sliding due to joint orientations, due to highly stressed strata, brittle localized failure of rock mass ejecting rock blocks at different places may also be expected. Boulder outcrops were observed indicating site has rock fall potential. No slope mitigation work was seen to be executed on site on the hill side.

The instability extends to both hill and valley side of the road. Further disengagement of joints can lead to slides due to water ingress during rains.

Figures 1-4 show photos taken during the visit at the existing site location. The CSIR CBRI team informed the officials about the necessity of drainage and slope stabilization measures.



Fig. 1 Major road passing through the slide zone



Fig. 2 Highly stresses jointed rock mass at site



Fig. 3 Steep slope on hill and valley side. Valley side has thin layer of debris underlain by jointed rock mass



Fig. 4 Bridge bypass under construction at site

Conclusions based on site observations

Perforated drainage holes, lined stepped down drains (preferably with geosynthetic), culverts and other drainage measures may be employed to reduce probability of any potential slide and increase ground stability. On the hill side slope, rock bolts, self-drilling anchors (SDA's) along with rock net can be used to restrain the jointed rock mass. On the valley side slope, retaining wall/ gabion wall may be given. Rock fall barrier may also be required at site considering the risk of shooting stones.

Table 1: Summary of observed landslide site at Charna petrol pump site, Sangrah Subdivision

Slope characteristics (Geometry, Length, width, average slope angle etc.)	<ul style="list-style-type: none">○ Height of hill and valley side slope around 400-500 m and 250 m respectively. Length of site is approximately 300 m.○ Quite steep slope angle around 75 - 85°
Location coordinates	-
Slope material characteristics	Highly jointed rock mass on hill side. Thin layer of debris on valley side
Possible problem identification	Water ingress in slope, highly jointed rock mass, stressed ground conditions, unstable geometry
Probable remedial measures	Provision of drainage holes, drainage paths, culverts etc. along the slide. Gabion/retaining structure on valley side; Rock bolts, Self-drilling anchors, netting on hill side. Provision for rock fall barrier

Scope of works

- Drone survey/mapping to identify the slope features if required
- Formulation of technical specifications and supervision for geological and geotechnical site investigations
- Analysis and interpretation of geological and geotechnical investigation results
- Site specific necessary geophysical investigations
- Determination of layering system from geological, geotechnical and geophysical investigation
- Evaluation of site-specific parameters for slope stability analysis

- Stability assessment of existing slopes through numerical/analytical studies
- Analysis of suitable control measures for improving the stability of the slope through numerical/analytical studies
- Design and formulation of construction procedure (with quality control parameters and s) for slope improvement
- Guidelines for slope monitoring
- Submission of detailed project report (DPR)

Project Duration

The total project duration shall be four (4) months.

Project Cost

The charges for the above assignment will be Rs. 33, 00,000/-+ taxes as applicable (18%)