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हिमाचल प्रदेश के सोलन जनपद के शामती एवं चक्की मोड़ में भूस्खलन के प्रारम्भिक आंकलन पर टिप्पणी

(भा. स. वि. टोपोशीट सँख्या: 53एफ/01 एवं 53बी/13)
(मद संख्या: M4EGG/C/NR/SU-PHP/2023/46620)
(मिशन-4/ कार्यवर्ष: 2023-24)

A NOTE ON THE PRELIMINARY ASSESSMENT OF LANDSLIDE AT SHAMTI AND CHAKKI MOR, SOLAN DISTRICT, HIMACHAL PRADESH

(SoI Toposheet No.: 53F/01 & 53B/13)
[Item No. M4EGG/C/NR/SU-PHP/2023/46620]
(Mission - IV/ Field Season: 2023-24)

द्वारा :

ललित मोहन, वरिष्ठ भूवैज्ञानिक
प्रदाप जगन आर, भूवैज्ञानिक

By:
Lalit Mohan, Sr. Geologist
Pradap Jagan, R., Geologist

अभियांत्रिकी भूविज्ञान प्रभाग /Engineering Geology Division
भारतीय भूवैज्ञानिक सर्वेक्षण, उत्तरी क्षेत्र / Geological Survey of India, Northern Region
राज्य इकाई: पंजाब, हरियाणा तथा हि. प्र. / State Unit: Punjab, Haryana and H.P.
चण्डीगढ़ - 160 020 (के. शा. प्र.) / Chandigarh - 160 020 (U.T.)

सितम्बर/September, 2023

A NOTE ON THE PRELIMINARY ASSESSMENT OF LANDSLIDE AT SHAMTI, AND CHAKKI MOR AREA OF DISTRICT SOLAN, HIMACHAL PRADESH

Toposheet No. 53F/01 & 53B/13
Item No. M4EGG/C/NR/SU-PHP/2023/46620
Field Season: 2023-24

By
Lalit Mohan, Senior Geologist & Pradap Jagan R, Geologist

INTRODUCTION

Hazards due to landslides and mass movements are the most common phenomenon in Himalayas and they cause extensive damage to the roads, buildings, forests, agricultural lands and are a major threat to human life. The Solan District of Himachal Pradesh witnessed extensive rainfall during the month of July and August 2023 which lead to slope failure incidences at multiple locations causing huge loss to the lives and properties.

Owing to the intensity of disaster, a quick response team was formed by the Engineering Geology Division of GSI Chandigarh, NR and subsequently, the team was invited by Deputy Commissioner, Solan, upon which the authors of this note made a field visit to the affected area on 17th August 2023. Initially, a technical discussion was made with the DC Solan and other officials of DDMA Solan, after which a field visit was made to the affected area. During the course of preliminary field work, various causative factors related to the landslide incidences were studied after which possible remedial measures have been choked out.

1. SHAMTI LAND SUBSIDENCE, SOLAN TOWN

The Shamti area of Solan town, District Solan (HP) experienced a land subsidence incidence on 11th and 12th July 2023. A continuous spell of rainfall was reported in the area which triggered the land subsidence along the Solan-Rajgarh road. A few ground cracks were reported by the local people a day prior to the date of incidence, in view of which the Solan District Disaster Management Authority vacated the affected area. Though no loss of life has been reported from the affected area, a substantial loss to the property, especially the residential buildings was reported. A total of 21 RCC buildings have been partially or completely collapsed and 28 RCC buildings have developed cracks and are on the verge of collapsing.

LOCATION AND ACCESSIBILITY

The landslide hit area of Shamti falls in the Survey of India (SoI) Toposheet No. 53F/01 and lies in the southeastern end of the Solan City on Solan-Rajgarh Link Road (Fig. 1). The study area if accessible through all season well metalled Solan-Rajgarh Road and well is connected to Chandigarh and Shimla. Nearest Railway Station and interstate bus stand is at Shimla which is approx. 50kms from the affected area. The affected area lies within the Geo-Coordinates N 30° 53′ 16″ to N 30° 53′ 33″ & E 77° 06′ 18″ to E 77° 06′ 47″.

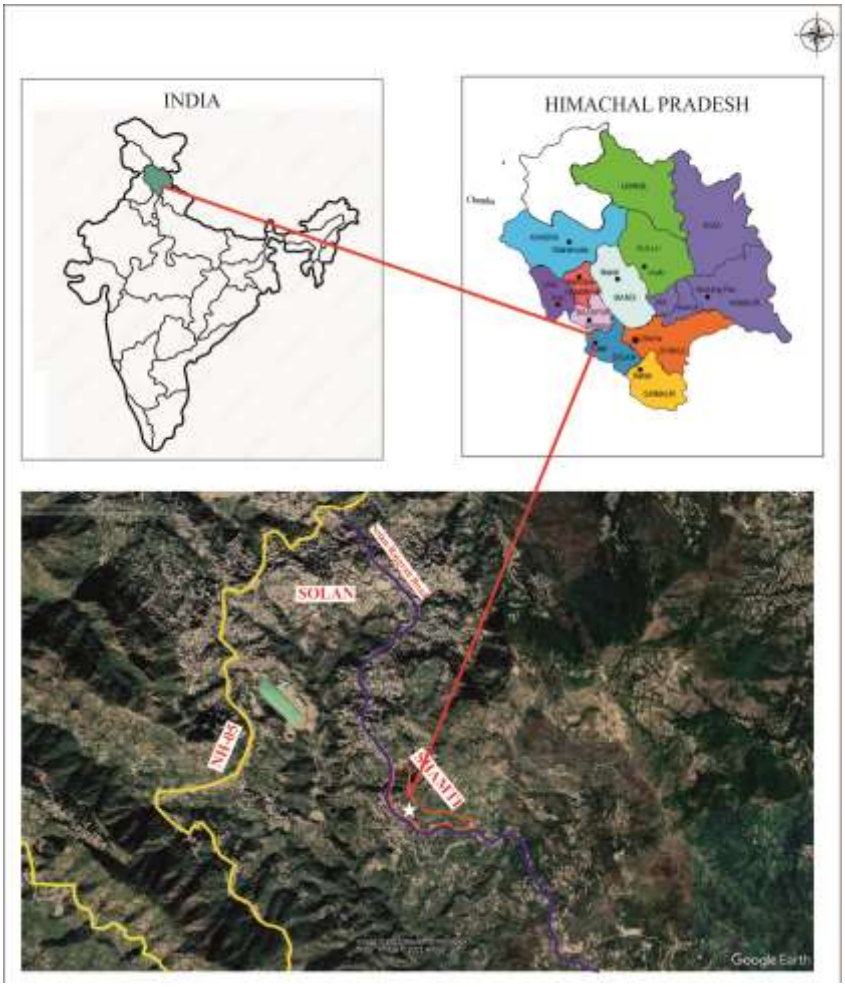


Fig. 1 Location map of the landslide area.

CLIMATE AND RAINFALL

Solan is basically considered as an average temperature hill station, i.e neither cold as Shimla nor hot as Chandigarh and the average temperature goes to a maximum of 35°C. During winters, especially from December to February, a few parts of Solan city experience light snowfall. The Solan area experiences approx. 1000mm to 1100mm average annual rainfall while during the monsoons season, especially in the month of July and August the monthly average rainfall ranges from 200mm to 230mm (http://hydro.imd.gov.in).

GEOLOGY AND GEOMORPHOLOGY AND SEISMICITY OF THE AREA

Physiographically, the area falls in Lesser Himalayan Zone and the hill ranges trend N-S to NW-SE. The elevation of area ranges from 1480m to 1560m Msl. The drainage pattern dominantly reflects trellis to dendritic types showing both the structural and lithological controls. The slope inclinations range from moderate to steep (40°-55°) and the slope aspect ranges from 180° to 275°. The hilltop portion of the affected slope is being utilized for agricultural practices, particularly for cultivation of tomato.

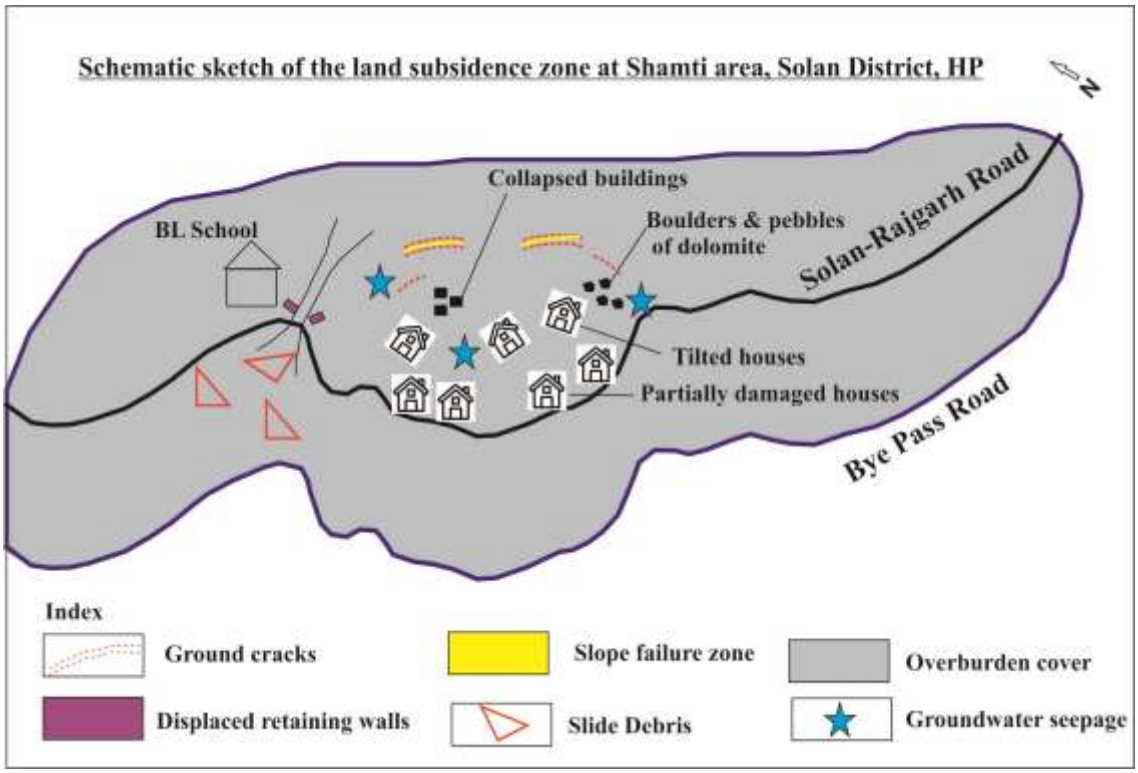
Geologically the area exposes dolomitic limestone and shale of Kauriyala Formation belonging to Karol Group of Neo-Proterozoic age. Very scanty rock exposures have been observed at isolated locations as the area is covered by dense settlements. Overall, the area is covered by a thick overburden comprising of moderately compacted soil and palaeo-debris material having an approx. thickness of 3-5m.

The Solan District falls in seismic zone IV, which has been classified as high damage risk zone MSK VIII (Source: BMPTC Earthquake Hazard Map, HPSDMA website). The NW-SE trending Krol Thrust is the main tectonic feature lying in the vicinity of study area and makes it seismically more sensitive.

FIELD ASSESMENT OF LANDSLIDE INCIDENCE AREA

1. Field traverse has been taken around the affected area covering approx. 600m Solan-Rajgarh road stretch starting from the road bend near BL School area and the upslope area upto the crown where ground cracks have been observed.
2. As stated earlier, heavy damage to residential RCC structures have been observed in upslope area of the road. The buildings adjoining the road have suffered minimum damages; whereas the structures lying in the upslope areas have suffer major damages.
3. As informed by the DDMA Solan official, Sh. Pradeep Kumar, there is no historical record of any landslide event around this area.
4. As per the Macroscale National Landslide Susceptibility Mapping (NLSM) studies carried out during the FS: 2017-18, the presently affected area lies in moderate to low landslide susceptible zone.
5. As observed during the course of field work, a thick overburden cover comprising of moderately compacted soil and palaeo-debris material is present around the area having an approx. thickness of 3-5m (Fig. 1 a).

6. A very few isolated outcrops of dolomitic limestone and shale have been observed around the area (Fig.1 b).
7. Prima facie it appears that the extensive rainfall for three days had led to the super saturation of thick overburden material exposed in the area. A deep rotational failure has been apprehended which ultimately caused the ground to subside.
8. The underlying weak/ incompetent rock strata observed at very locations show the impact of Krol thrust located in the vicinity of landslide
9. The calcareous nature of sub surface rock strata has favoured the further super saturation.
10. The ground cracks having an opening of 2-10cm and length ranging from 1-20m have been observed at the crown portion, along which a lateral displacement of 20 cm to 1.5m has been recorded at four to five locations (Fig. 1c&d).
11. Though an attempt has been made by the DDMA Solan to fill up these cracks, but the openings are still wide enough to allow smooth percolation of surficial water generated by any further rainfall event. Under such conditions, the further deterioration of slope stability is highly possible.
12. The damaged residential RCC buildings were also inspected during the course of field work during which it was observed that a lot of buildings have suffered total losses which has possibly been due to the poor foundation design and structure (Fig. 1e & f). Rest of the houses have either tilted or their foundation level pillars and columns have suffered damages. Under such conditions, these residential buildings have become highly susceptible to further failure.
13. The flowing hydrological conditions have been observed in the residential area where the sufficient groundwater outflow has been observed. As per the information received from the officials of concerned authority, the affected area has three to four spring water sources which have already aggravated the hydrological conditions in the area.
14. A small-scale debris slide has been also observed along the first order stream near BL School where some of the houses have suffered partial damages due to rapid downslope movement of water saturated debris material and few boulders.
15. No effective drainage system has been provided in the affected area and the drain water from the residential buildings were found unattended.



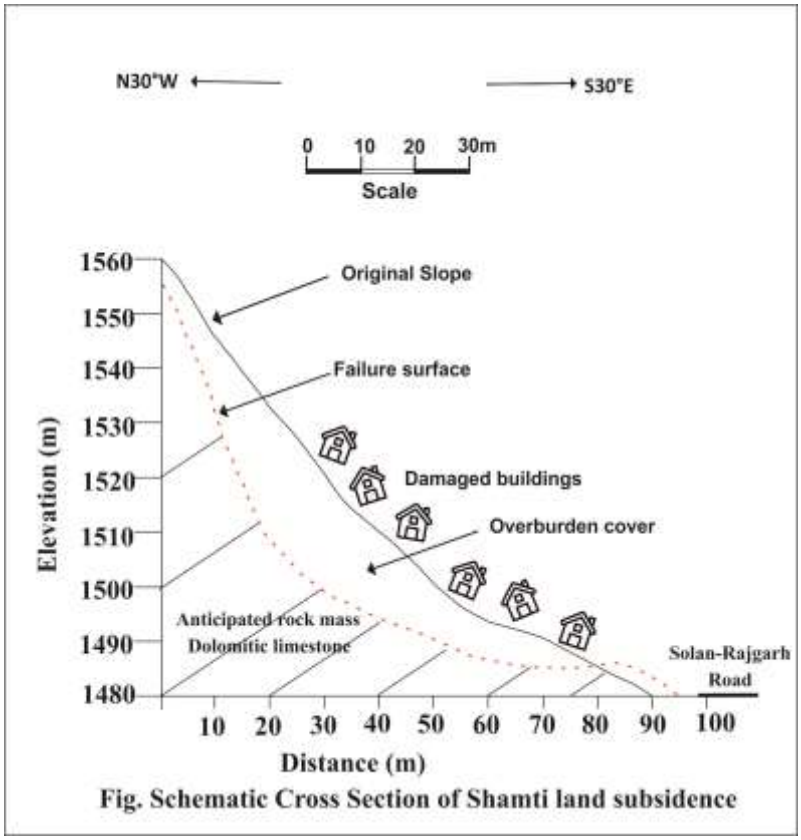


Fig. Schematic Cross Section of Shamti land subsidence

CONCLUSION

1. Prima facie, the slope failure appears to be a rainfall triggered natural slumping/ subsidence of thick overburden dominated ground mass under the influence of highly saturated rainwater.
2. The further retrogression in case of any further heavy spell of rainfall is highly anticipated as the ground cracks are wide enough to facilitate the super saturation of ground strata and the overburden cover is considerably thick.
3. No ongoing anthropogenic activity has been observed around the affected area, though a lot of multi-storied buildings (3-5 storied) have been constructed.
4. The underlying weak/ incompetent and calcareous rock strata have favoured the further super saturation.
5. The NLSM studies carried out previously, classifies the affected area under moderate to low landslide susceptible zone, however after the field visit the inferences have been drawn that the area is highly susceptible to slope failure under the extreme rainfall events.

RECOMMENDATIONS

1. The ground cracks need to be covered up effectively in order to avoid any further rain water percolation. The cracks must be sealed either by filling them with puddle clay or other impervious fill or some trenches can be excavated along the tension cracks and backfilled with the impervious material. Small quantities of bentonite or other natural material to reduce further permeability can be used so that surface water does not pond in the area. Impervious membrane may be used as an emergency or temporary measure.
2. Suitable geotextiles/ geosynthetic material such as geonet, geogrid, geo-composites etc. can be installed as they provide enhanced drainage, protection, reinforcement, filtration and barrier functions.
3. Sufficient drainage arrangements must be provided along the affected slopes, especially at the crown portion. The drain water from individual houses must be channelized effectively to avoid any ground water saturation. The flood irrigation practice for agricultural lands at the hill top must be discouraged.
4. Regular inspection and maintenance are required in case of continued movement, since it may cause previously sealed cracks to reopen. Therefore, in order to monitor

small levels of ground creep, installation of a geodetic system may be considered at first in consultation with geotechnical engineers.

5. The surrounding area susceptible to further slope failure along with the buffer zone may be identified and no new construction activity or slope modification work should be carried out in this zone.
6. Preliminary field survey suggests that these vulnerable slopes have rock mass with poor engineering properties are not at all favourable for heavy constructions. Under such ground conditions, a scientific approach for constructing multilevel RCC structures, especially the foundation design parameters become critical. Therefore, the "National Building Code of India (NBC2016)", a comprehensive building code prepared by Bureau of Indian Standards must be followed before taking out any such construction activity.

FIELD PHOTOGRAPHS

a. Thick overburden cover in the area

b. Highly disintegrated dolomitic limestone.

c. Ground subsidence observed at the crown portion

d. Ground cracks observed in Shamti area.

e. Collapsed RCC building

f. Collapsed RCC building

g. Flowing conditions in the vicinity of damaged houses.

h. Seepage from the retaining walls of residential houses.

i. Cracks observed in the pillars of residential

k. Tilted house in Shamti area.

houses.	
 l. Cracks observed in the walls of residential houses.	 m. Debris slide near BL School

42-Point Geo-parametric attributes of landslide incidence at Shamti area, District Solan, Himachal Pradesh

No	Field	Description
1	Slide No (LS .No.)	*HP/Solan/53F01/2023/01*
2	State	*Himachal Pradesh*
3	District	*Solan*
4	Toposheet	*53F/01*
5	Name of the slide	*Shamti Slide*
6	NH/SH/Locality	*Along Solan-Rajgarh Link Road*
7	Latitude	*30° 53' 22" N*
8	Longitude	*77° 6' 21" E*
9	Length	*110 m*
10	Width	*450 m*
11	Height	*80 m*
12	Area	--
13	Depth	*1m*
14	Volume	--
15	Run out distance	--
16	Type of Material	*Debris*
17	Type of movement	*Subsidence*
18	Rate of movement	*Slow*
19	Activity	*Active*
20	Distribution	*Retrogressive*
21	Style	*Single*
22	Failure mechanism	*Deep rotational failure*
23	History	*No historical data related to previous landslide incidence is available*
24	Geomorphology	*Moderate dissected hill slope*
25	Geology	*Dolomitic limestone and shale of Kauriyala Formation of Karol Group.*
26	Structure	*The area is covered with overburden. Insitu rockmass not exposed. Slide orientation is 45°→195°*
27	Land use/ Land cover	*Moderately dense settlements along the road with moderate vegetation cover in the uslope area.*
28	Hydrological condition	*Flowing*
29	Triggering Factor	*Rainfall*
30	Death of persons	*Nil*
31	People affected	*49 families have been affected to the damaged houses.*
32	Live-stock loss	*Nil*
33	Communication	*Temporary road blockage near BL School*
34	Infrastructure	*A total of 21 RCC buildings have been partially or completely collapsed and 28 RCC buildings have developed cracks and are on the verge of collapsing.*
35	Agriculture/forest/Barren	*Moderate vegetation*
		1. *Heavy and incessant rainfall.*

36	Geoscientific Causes	2. *Super saturation of thick overburden material exposed in the area.* 3. *High precipitation was the cause for increased pore pressure and reduction in shear strength thus aiding the slope forming material to fail.* 4. *The calcareous and weak/ incompetent underlying rock strata.*
37	Remedial measures	1. *The ground cracks need to be covered up effectively in order to avoid any further rain water percolation* 2. *Sufficient drainage arrangements must be provided along the affected slopes, especially at the crown portion.* 3. *Regular inspection and maintenance are required in case of continued movement, since it may cause previously sealed cracks to reopen.*
38	Remarks, if any	*The area is tectonically very active due to presence of Krol thrust in the vicinity. Such incidences are anticipated and can only be minimised by taking necessary precautions.*
39	Photos. Sketch of Plan & section of the slide	*Photographs provided in the note*
40	Summary/Abstract	*A continuous spell of rainfall was reported in the Shamti area which triggered the land subsidence along the Solan-Rajgarh road. A total of 49 RCC buildings have suffered partial or complete loss. A thick overburden cover comprising of moderately compacted soil and palaeo-debris material is present around the area. Extensive rainfall for three days had led to the super saturation of thick overburden material whereas a deep rotational failure has been apprehended which ultimately caused the ground to subside. The site has been visited by the authors and necessary remedial measures have been suggested as per ground conditions.*
41	Pdf	*NA*
42	Landslide category	*Category II*

----Sd---

(Pradap Jagan R)
Geologist

----Sd---

(Lalit Mohan)
Sr. Geologist

2. CHAKKI MOR, SOLAN DISTRICT, HIMACHAL PRADESH

INTRODUCTION

As a result of continuous spell of rainfall, the Chakki Mor area of District Solan, Himachal Pradesh experienced a landslide incidence around on the midnight of 1st August 2023 swiping away the 50m stretch four lane road of NH 05. As a result, the vehicular traffic along the National Highway was disrupted causing a major inconvenience to the local public and commuters.

The debris slide had initiated a few days earlier causing intermittent road blockage which was being cleared by National Highway Authority of India time and again. During the main land sliding event, no casualty was reported from, but a major road stretch was damaged which took a considerably long time to reopen for commuters. The continuous rainfall had aggravated the situation due to which the road restoration work was disrupted for many days.

LOCATION AND ACCESSIBILITY

The landslide hit stretch of National Highway 05 falls in the Survey of India (SoI) Toposheet No. 53B/13 and is located near Chakki Mor area which is approximately 7 kms. From Parwanoo town (Fig.1). The study area if accessible through all season well metalled four laned NH 05 and well is connected to Chandigarh and Shimla. The affected area has the Geo-Coordinates N 30° 51′ 08" & E 76° 59′ 55" and the elevation is 1100m Msl.

CLIMATE AND RAINFALL

Chakki Mor area of Solan District is basically considered as an average temperature area, i.e neither cold as Shimla nor hot as Chandigarh and the average temperature goes to a maximum of 35°C. During winters, especially from December to February, the areas around Parwanoo town experience cold waves. The Parwanoo-Chakki Morarea experiences approx. 1000mm to 1100mm average annual rainfall while during the monsoons season, especially in the month of July and August the monthly average rainfall ranges from 200mm to 230mm (http://hydro.imd.gov.in).

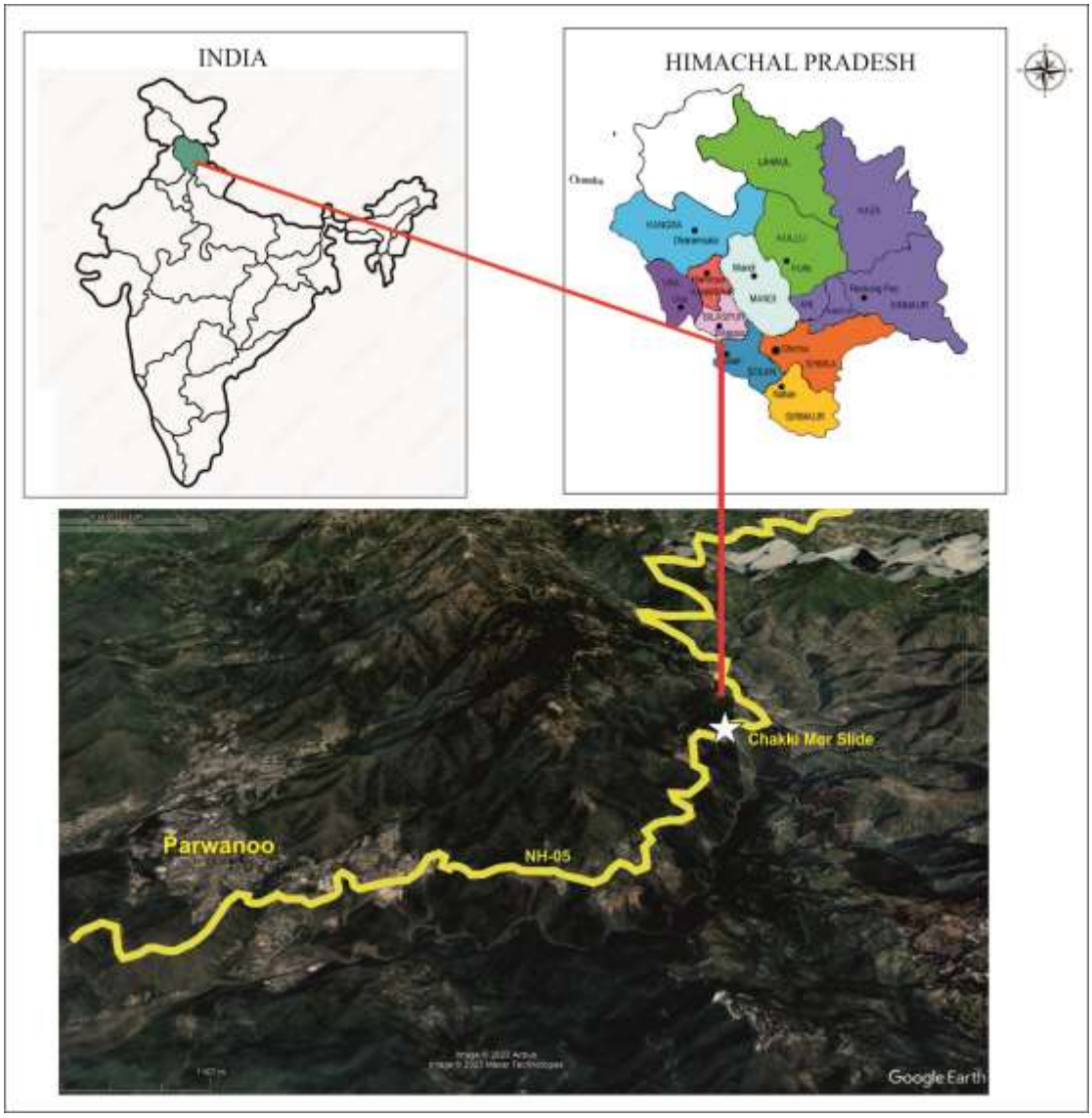


Fig. 1 Location map of the landslide area.

GEOLOGY AND GEOMORPHOLOGY AND SEISMICITY OF THE AREA

Geomorphologically, the Chakki Mor area represent moderately dissected hill slopes falling in Lesser Himalayan Zone and the hill ranges trend N-S to NNW-SSE. The elevation of area ranges from 870m to 1250m Msl. The drainage pattern dominantly reflects trellis to dendritic types showing both the structural and lithological controls. The slope inclinations range from moderate to steep (40°-55°) and the slope aspect ranges from SE to SW. The National Highway 05 has witnessed extensive slope cuttings for its widening and four lanning right from Parwaanoo to Shimla during the last one decade.

Geologically the area exposes dolomitic limestone and shale of Kauriyala Formation belonging to Karol Group of Neo-Proterozoic age. Very scanty rock exposures have been

observed at isolated locations as the area is covered by dense settlements. Overall, the area is covered by a thick overburden comprising of moderately compacted soil and palaeo-debris material having an approx. thickness of 3-5m.

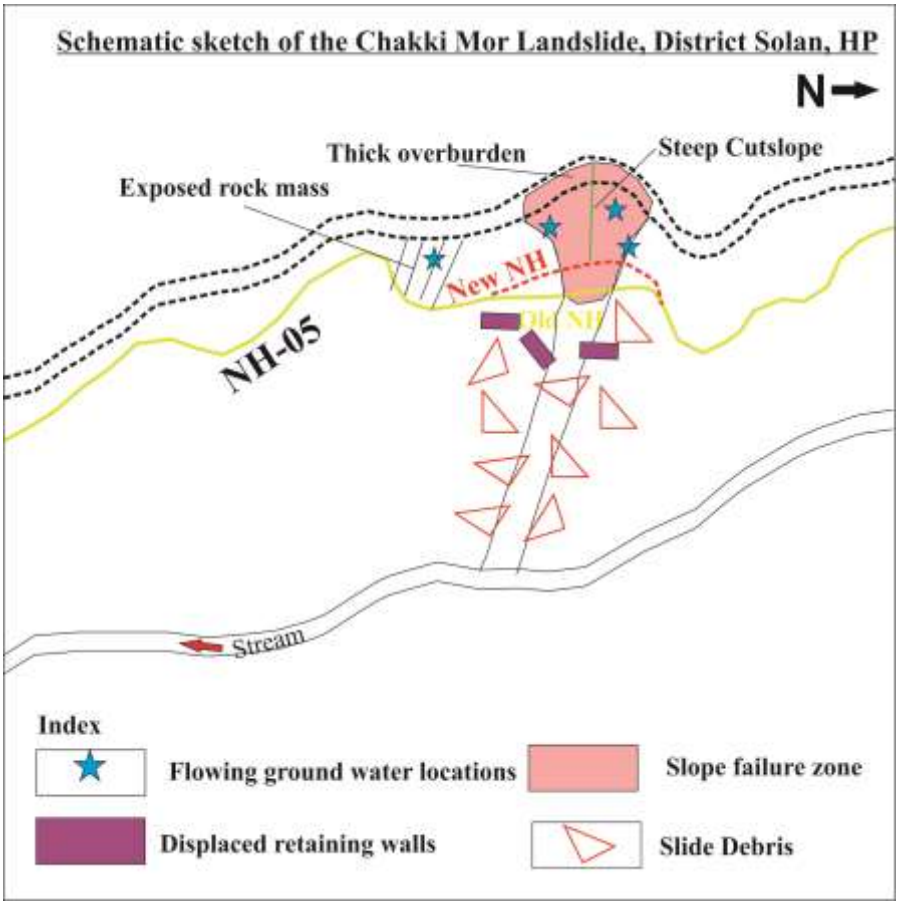
Geologically, the landslide affected road stretch of NH 05 exposes interbanded sequence of purple sandstone, siltstone, claystone of Dagshai Formation belonging to Sirmur Group of late Eocene to oligocene age. Highly jointed and disturbed sandstone-siltstone sequence has been observed along the road stretch and at some places the rock mass is found to be highly disintegrated. Mainly three sets of discontinuities have been observed around the study area, J_1: (Bedding Plane) 30^0-40^{0-}/N155^0, J_2 = 50-75^0/N245^0, $J_{3:}50^0$/N180^0. The upslope area is covered by a thick overburden comprising of moderately compacted soil and palaeo-debris material having an approx. thickness of 3-5m.

The Chakki Mor area of Solan District falls in seismic zone IV, which has been classified as high damage risk zone MSK VIII (Source: BMPTC Earthquake Hazard Map, HPSDMA website). The NW-SE trending Main Boundary Thrust (MBT) is the main tectonic feature lying in the vicinity of study area and makes it seismically more sensitive.

FIELD OBSERVATIONS AND CAUSATIVE FACTORS

16. During the course of field work, traverse has been taken along the NH 05 and nearby upslope area covering approx. 400m road stretch.
17. The road stretch having an approx. length of 50m has been completely washed away, after which further slope cutting was carried out, during the course of which repeated slope failures have been witnessed. The ground water saturated overburden cover resting above the bedrock are falling down the slope, therefore clearance of the muck from the road needs to be done frequently, due to which the vehicular movement gets affected.
18. As informed by the NHAI officials, there is no historical record of any landslide event along this particular slope, though a steep cut slope was formed due to the sideward cutting of hill slope for road widening.
19. As per the Macroscale National Landslide Susceptibility Mapping (NLSM) studies carried out during the FS: 2017-18, the presently affected area lies in high landslide susceptibility zone.

20. During the course of field work, a thick overburden cover comprising of moderately compacted soil and palaeo-debris material having an approx. thickness of 3-5m was observed at the crown portion. (Fig. a).
21. Interbedded sequence of purple sandstone-mudstone of Dagshai Formation is exposed in patches along the road cut section (Fig. b). The rock mass is highly jointed and disintegrated with very poor strength.
22. Prima facie it appears that the extensive rainfall for a prolonged duration had led to the super saturation of thick overburden material exposed in the area.
23. Except for the breast wall, no slope stability protection measures were taken prior to this incidence and the steep cut slopes along the road were are left unattended, which ultimately failed under the influence of extreme rainfall conditions (Fig. c).
24. The bed rock exposed around the landslide area have been deformed/ highly jointed possibly due to the presence of Main Boundary Thrust (MBT) located in the vicinity of landslide.
25. Presently, most of the overburden mass resting above the bed rock has slided down and the concealed insitu rock mass can be visualised (Fig. i).
26. Along the whole stretch of NH 05, flowing hydrological conditions were observed intermittently at multiple locations (Fig. d&e). The ground water could be seen gushing out from the joint planes and flowing down from the crown portion of slide at 2-3 locations, which inferred that the ground mass was highly saturated with rainwater.
27. No effective arrangements for draining out the run-off water from the upslope portion of the road were observed. The weep holes in the retaining walls along the road were found to be chocked (Fig. f).
28. The valley portion of the affected slope is presently covered by thick pile of dumped muck; therefore, the stability condition of toe portion of the slide can’t be commented upon (Fig. g &h).



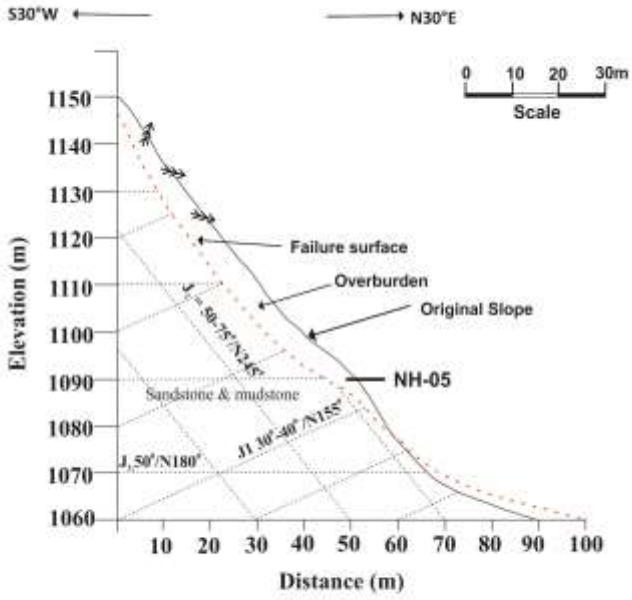


Fig. Schematic Cross Section of Chakki Mor Landslide

CONCLUSION

6. Prima facie, the slope failure appears to be a rainfall triggered debris slide possibly due to the super saturation of thick overburden dominated ground mass under the influence of extreme rainfall.
7. Insufficient slope protection measures have been provided along the affected road stretch which can definitely deteriorate the stability condition under extreme rainfall events.
8. The landslide is found to be both retrogressive and widening in nature, therefore further slope failure in case of any heavy spell of rainfall is highly anticipated.

RECOMMENDATIONS

9. The effective arrangements for draining out the run-off water from the upslope portion of the road should be made. Light weight contour drains can be constructed all along the affected hill slope.
10. The light weight retaining structures should be installed towards the hill side so that the loose rock mass or the overburden cover doesn't fail frequently.
11. No further slope cutting in and around the affected area till the retreat of monsoon is strictly recommended.
12. Once the affected slope becomes deficit in ground water saturation, then only the road widening work can be further carried out.
13. Installation of geotextiles, geogrids, geonets and geomembranes can be effective in stabilizing the loose soil and disintegrated rock mass.
14. Soil nailing can be effective for stabilizing the weak zones above the road level.
15. Horizontal wick drains can be installed for effective draining or removal of excess ground water in the affected hill slope.

FIELD PHOTOGRAPHS

a. Thick overburden exposed in the vicinity of landslide.

b. The highly jointed rock mass exposed along the road.

c. Steep cut slope exposed along the NH 05.

d. Flowing hydrological conditions along the affected slope.

e. Flowing hydrological conditions along the affected road.

f. Chocked weep holes in the retaing walls along the road.

g. The valley portion of affected hill slope covered with slide muck.

h. The valley portion of affected hill slope covered with slide muck.

 i. Rock mass exposed after the removal of debris cover	 j. The flowing hydrological conditions observed along the road.

DATA SHEET FOR PRILIMINARY INVESTIGATION OF *CHAKI MORH* LANDSLIDE AT RD: KM71+300M TO KM 71+420M, CHANDIGARH-SIMLA ROAD (NH-05), DISTT. SOLAN, H.P.			
No	**Field**		**Description**
1	**Slide No (LS.No.)**	**:**	*H.P./SOL/53B13/2023/02*
2	**State**	**:**	*Name: Himachal Pradesh*
3	**District**	**:**	*Name: Solan*
4	**Toposheet**	**:**	*No. 53B/13*
5	**Name of the slide**		*Chaki Morh Slide RD 71+300 to 71+420*
6	**NH/SH/Locality**	**:**	*NH-05/ RD: 71+300 to 71+420/Chakki Morh*
7	**Latitude**	**:**	N 30° 51′ 08̋
8	**Longitude**	**:**	E 76° 59′ 55̋
9	**Length**	**:**	*20-35m*
10	**Width**	**:**	*100m*
11	**Height**	**:**	*18-30m*
12	**Area**	**:**	*--*
13	**Depth**	**:**	*±5m*
14	**Volume**	**:**	*--*
15	**Run out distance**	**:**	*15m*
16	**Type of Material**	**:**	*Debris*
17	**Type of movement**	**:**	*Slide*
18	**Rate of movement**	**:**	*Moderate*
19	**Activity**	**:**	*Reactivated*
20	**Distribution**	**:**	*Retrogressive/Widening*
21	**Style**	**:**	*Single*
22	**Failure mechanism**	**:**	*Shallow rotational*
23	**History**	**:**	*Nil*
24	**Geomorphology**	**:**	*Moderately Dissected Hill*
25	**Geology**	**:**	*Sandstone and mudstone of Dagshai Formation of Sirmour Group of Rocks.*

26	**Structure**	**:**	*Mainly Three Discontinuities are J_1: (Bedding Plane) 30^0-40^{0-}/N$155^{0,}$ J_2 = 50-75^0/N245^0, J_3:50^0/N180^0*
27	**Landuse/ Land cover**	**:**	*Forest*
28	**Hydrological condition**	**:**	Flowing
29	**Triggering Factor**	**:**	*Rainfall*
30	**Death of persons**	**:**	*N.A.*
31	**People affected**	**:**	*N.A.*
32	**Livestock loss**	**:**	*N.A.*
33	**Communication**	**:**	*Road blocked for more than a day*
34	**Infrastructure**	**:**	*Road, breast wall and retaining wall are damaged*
35	**Agriculture/forest/ Barren**	**:**	*Forest*
36	**Geo-scientific Causes**	**:**	*Anthropogenic activities; unplanned cutting of slope, rainfall, reduction of strength on supersaturation.*
37	**Remedial measures**	**:**	1. *The effective arrangements for draining out the run-off water from the upslope portion of the road should be made.* 2. *Installation of geotextiles, geogrids, geonets and geomembranes can be effective in stabilizing the loose soil and disintegrated rock mass.* 3. *Soil nailing can be effective for stabilizing the weak zones above the road level.* 4. *Horizontal wick drains can be installed for effective draining or removal of excess ground water in the affected hill slope.*
38	**Remarks**	**:**	*No further slope cutting in and around the affected area till the retreat of monsoon is strictly recommended. Once the affected slope becomes deficit in ground water saturation, then only the road widening work can be further carried out.*

Fig. 13A: Location Map of the *Chaki Morh Slide at NH-05/ RD: 87+480,*
(Source: Google Earth)

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40	**Summary/Abstract**		*Chaki Morh slide is a shallow rotational slide and is reactivated on 14-08-2023. Road blocked on 14/08/2023 and opened on 15/08/2023. Three Discontinuities recorded in the slide area J_1: (Bedding Plane) 30^0-40^{0-}/N$155^{0,}$ J_2: 50-75^0/N245^0, J_3:50^0/N180^0*
41	**Pdf**	**:**	**--**
42	**Landslide category**		***Category II***

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