PRELIMINARY POST DISASTER STUDY OF THE LANDSLIDE AT KIKRUMA (ON LEFT BANK SLOPE OF SIDZU RIVER), PHEK DISTRICT, NAGALAND

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Keywords: Slope, translational, lithology, locking section, rupture surface.

Abstract

Local media, particularly the "Morung Express" dated 30th July, 2018 reported the occurrence of a landslide between Kezoma and Kikruma villages in Nagaland. The landslide debris reportedly blocked the Sidzu River and led to formation of an artificial dam causing imminent threat to the habitations downstream. Post-disaster preliminary field investigations indicate that the landslide is located at northern part of Kikruma village and falls in SOI Toposheet No. 83K/02. The landslide is characterised as a deep translational failure exhibiting a relatively planar surface progressive over 1.2 km distance, minor rotational movement or backward tilting, inclined rupture surface with two locking sections at a distance of 350 m and 750 m. The landslide material comprises loose/unconsolidated soils and weathered rock debris. The site-geology comprises largely monotonous argillaceous sequences of Disang Formation consisting of highly shattered, sheared grey splintery shale, lensoidal fine grained sandstones with greywacke and rhythmites. The translational failure of the landslide was found to have occurred along the geologic discontinuities such as joints, bedding surfaces and the contact between rock and overburden soil. The most influent factor for this landslide is the slope forming material, slope morphometry and antecedent heavy rainfall. Moreover, landslide is coupled with drainage network with synclinal lamellar weak strata.

Introduction

Local media reports including the "Morung Express" dated 30th July, 2018 reported the occurrence of a large landslide between Kezoma and Kikruma village, resulting in formation of an artificial dam on the Sidzu River causing imminent threat to the habitations downstream. A team comprising three officers from GSI, SU: MN, Dimapur were sent on 7th August, 2018 to assess the ground situation and carry out post-disaster investigation through the collection of detailed attributes. The landslide is located at northern part of Kikruma Village and falls in SOI topographical sheet 83K/02. The area is approachable through NH-29 by Kohima-Meluri Road.

Field work was carried out on 07.08.2018 and 08.08.2018 with an objective to carry out preliminary geological evaluation of the landslide through collection of detailed attributes, understand the causal factors and failure mechanism and recommend suitable generic remedial measures.

Acknowledgement

The authors are sincerely thankful to Shri M.R. Jarngal, the Additional Director General & HoD, Geological Survey of India, North Eastern Region, Shillong, for the necessary support. The authors are immensely grateful to Shri Janak Raj, RMH-IV, GSI, NER, Shillong and Shri P.V. Ramana Murthy, DDG, SU-MN, Dimapur for their valuable support and instructions. The authors express their sincere gratitude to Shri Manoj Kumar Kaistha, Director, Landslide Division, NER, Shillong for his valuable suggestions & guidance. The authors also express their sincere thanks to the Supervisory Officer, Shri S.P. Dhanvijay, Director, GSI, SU-MN, Dimapur for his support, encouragement & guidance.

Physiography and Drainage

The physiography of the area comprises sub-parallel north-easterly trending long linear ridges/hill separated by deeply cut meandering streams. The highest and lowest elevation of the area is 1300m and 850m above mean sea level respectively. Drainage pattern in the area is parallel to sub parallel while some of the small tributaries/ rivulets exhibit rectangular drainage pattern which is indicative of joint or fault controlled drainage system. The area is drained by rivers whose courses flow along the structurally weak zones. Natural forests as well as plantations are the dominant vegetation in most of the area.

Regional geology

Of the four geotectonically distinct domains identified in the Naga Hills, the study area falls in the Inner Palaeogene Fold Belt. The Inner Palaeogene Fold Belt comprises folded and thrusted post-Upper Cretaceous and mainly Tertiary sequence commencing from the monotonous shale sequence of Disang Group, followed by the arenaceous sequences of Barail and Surma Group of sedimentary rocks, over which Pleistocene to Recent sediments have been deposited. The broad structural setup of this area shows NNE-SSW trending folds which are usually open type towards west but become tightly compressed towards the east with gentle north easterly plunge. In anticlinal zones, Disang Group is exposed with several symmetrical folds. Disangs are predominantly argillaceous sequence with minor subarenaceous and arenaceous intercalations. The upper Disang is mainly composed of alternating bands of sandstone, siltstone and shale. Shale is predominantly present, but thicker bands of sandstone and siltstone are present in Upper Disang than to the Lower Disang which is predominantly consisting of thin interbedded sequence of sandstone and siltstone with phyllite and slates.

Site Geology

The lithology around the landslide comprises highly shattered, sheared sequences of grey splintery shale, lensoidal fine grained sandstones with greywacke and rhythmites of Upper Disang Formation. The phyllitisation of the shale with the development of rudimentary slaty cleavage is noticed around Kezoma & Kikruma which indicates the presence of Lower Disang rock. The landslide area has indicated that a larger part of the material involved in landsliding is debris/overburden resting over the variably weathered shale dominantly of upper and lower Disang.

Slide morphometry, material and its characteristics

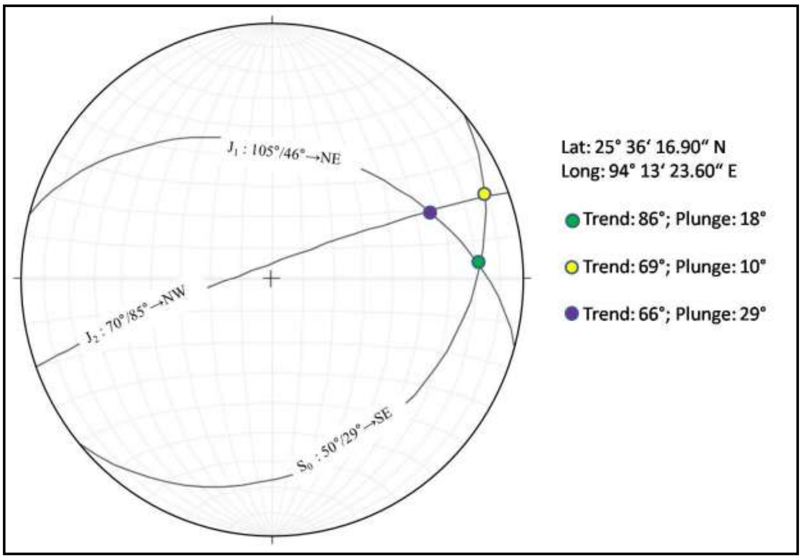
1. The slide has occurred to the North of Kikruma village along north-west facing slope of NE-SW trending ridge. The Kikruma Village is situated in a NE-SW trending synformal ridge.
2. Dimension of the slide measures 1200m length × 600 m width × 470 m height with 80 m run out distance. Failure mechanism is deep translational (planar). The slide direction is N315°.
3. Toe of the slide is near the Sidzu River while the crown has reached up to the hill top near the village.
4. The slide material is mainly composed of weathered shale, embedded fragments of sandstones, shale, siltstone and greywacke and, overburden soil rich in clay. The overburden thickness is as high as 2-5m.
5. The material has slided down and formed an artificial dam of height about 20m along the narrow valley across the river. The water flow was arrested due the damming, creating an artificial reservoir. However when the water level rose to the top of the dam it started eroding the material and subsequently dam was washed away. Due to

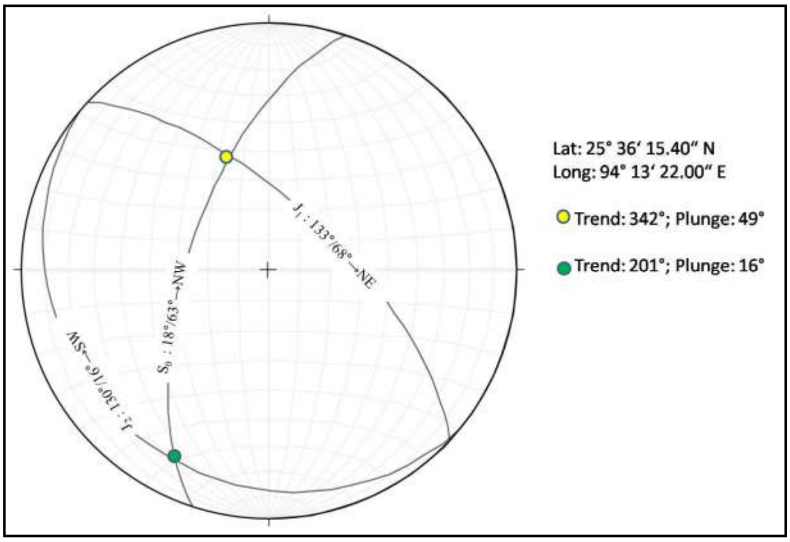
the sudden bursting of that dam, huge amount of water along with the slided material flowed down the river and deposited huge debris along its course up to a distance of 300m. This debris engulfed many paddy fields along the downstream side.

6. Due to sudden increase of volume of water by the breakdown of the dam, rate of toe erosion increased towards the downstream. As a result the road 150m away from the slide was severely damaged and 50m of the road has completely slided down and another 100m was partially slided and longitudinal cracks were developed. To rehabilitate the communication, Border Road Organization has started construction of new alignment of road along the affected part by back cutting of the hill slope.
7. A bridge on the Sidzu River was affected due to breach of the dam where rising water level eroded the abutments of the bridge.
8. The increased water volume and current velocity caused change in previous river course.
9. The rocks in the area are highly sheared. Second generation folds were observed. Folds are shallow plunging towards SSE.

Structural data

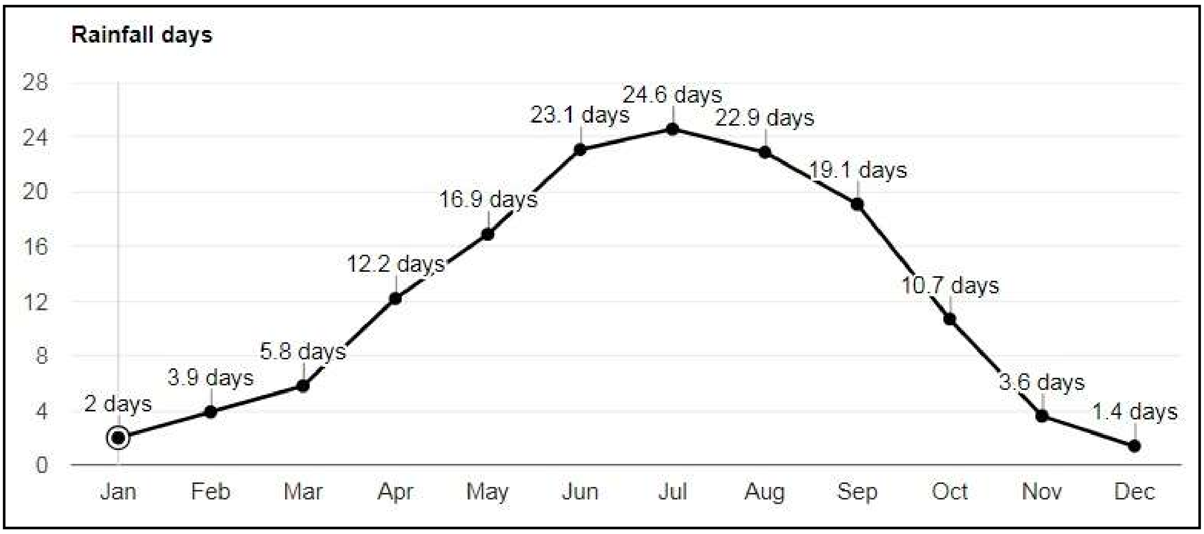
The area around the slide shows synformal ridges and antiformal valleys which is a common phenomenon in these areas. The Kikruma slide has occurred along a north-west facing slope, toe of which is situated near the Sidzu River (following the Sidzu anticline) and the crown has reached up to the ridge top where contact between Lower and Upper Disang lies. General slope of the surface is around 40°-45°. Near the crown the trend of the bedding plane is recorded as NNE-SSW (050°/29°SE, 032°/72°SE) dipping towards southeast. Rocks are highly sheared and jointed at the toe of the slide. The predominant sets of joints recorded in the area are: i) J1=105°/46°→NE, ii) J_2=130°/16°→SW iii) J_3=70°/85°→NW.



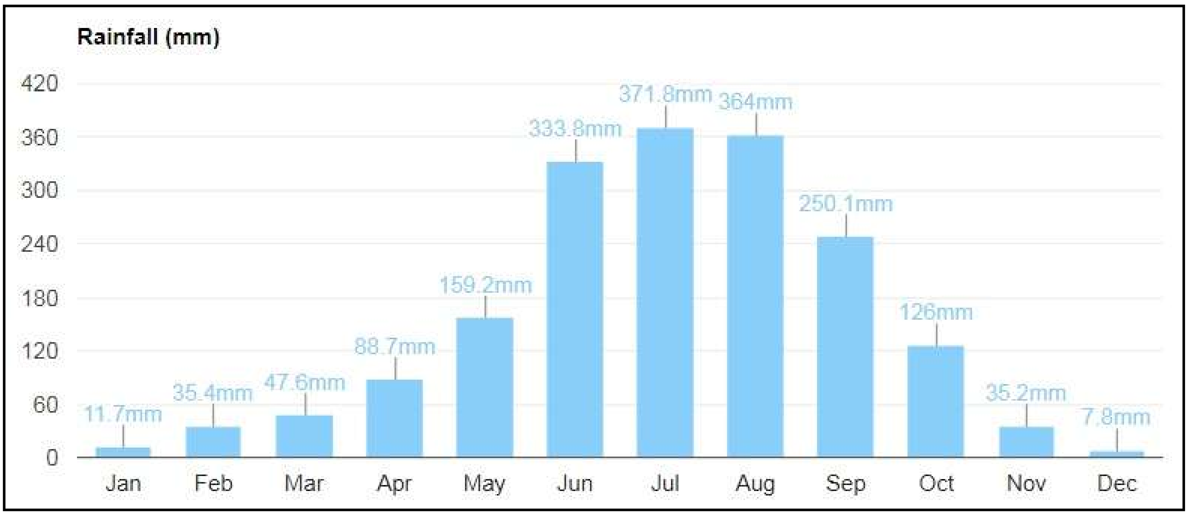


Rainfall data

1. The available rainfall data is not uniformed and complete rainfall data is not available at maximum recording stations.
2. It is observed that rainfall from the year 2009 to 2018 is progressively increasing.
3. During the peak months of monsoon, there is acute increase in rainfall from the month of May to July every year. Therefore, proportionate amount of runoff, percolation, seepages, and saturation of the slope in the area is experienced followed by subsequent landslides where rain water acts as the main triggering factor.



(Source: The India Meteorological Department)



Failure Mechanism of the Landslide

Initiation of the slide occurred due to toe cutting by the rising water level in the Sidzu river and gradually retrograded towards up slope. Bedrock comprises highly weathered shale of Lower Disang Formation. The rocks of the area are also highly jointed and sheared rendering a poor rockmass condition. Geologically, weathering of Disang shales gives rise to clay-rich overburden/soil. Such soils with significant porosity but low permeability lead to development of groundwater (pore water) pressure that has acted to destabilize the slope further, in this case. The overburden thickness is as high as 2-5m. Overburden consists of weathered shale fragments embedded in argillaceous matrix. The saturation of the overburden material by antecedent heavy rainfall contributed to the weight of the material, increasing the resulting downward force. The slope mass creates an imaginary surface of permeability difference with the slope base because of permeability difference. There is a chance of movement of water along this surface parallel to the slope. This acts as a sliding plane for the overlying material to slide down the slope. This indicates a deep translational failure.

The upper part of the slide is composed of weathered rocks and overburden material of varying sizes. The upper slope is steep, while the middle part is relatively low; forming a concave landform. At the distance of 350m length along the sliding direction, a comparably rigid block of lensoidal sandstone acted as a locking section with high strength, acting like a "retaining wall". Once the concentrated stress exceeds than the strength of the locking section, an abrupt brittle failure occurred. As such, the following failure mechanism was interpreted in the field. (1) The upper overburden material slides along the potential sliding surface. Its deformation is restrained by the locking section at the distance of 350m of failure length; (2) Accumulation of stress on the rigid section causes brittle failure of this part and subsequently the overall failure of the slope; (3) Another locking section is observed at a distance of 750m from the crown. It may be a part of comparatively high resistant sandstone or siltstone body. A combination of the above gave rise to deep translational failure. The failure of the locking-section under the natural forces further causes the sudden failure of the whole slope, producing large-scale and rapid landslides.

Prior to this incidence, heavy rainfall for a week along the catchment area of the Sidzu River increased the water level in the river and as a result current of the water was also increased. This river water caused toe cutting. Meanwhile slope also has received heavy downpour. So, high rainfall triggered the slide, initiated with toe cutting with all contributing factors mentioned above. The slope of around 40° also has aided in the downward movement of the material. In other words, a high angle of slope means higher mobility of landslides so that rapid accumulations of debris material have been noticed along with the blocking of river course and subsequent formation of temporary damming.

L-Section of landslide

A longitudinal section along the length of the slide is prepared (1:5000) to delineate shape of the slide and disposition of slided material along the length of the slide. Trend of section line is 315°-135° (slide direction 315°).

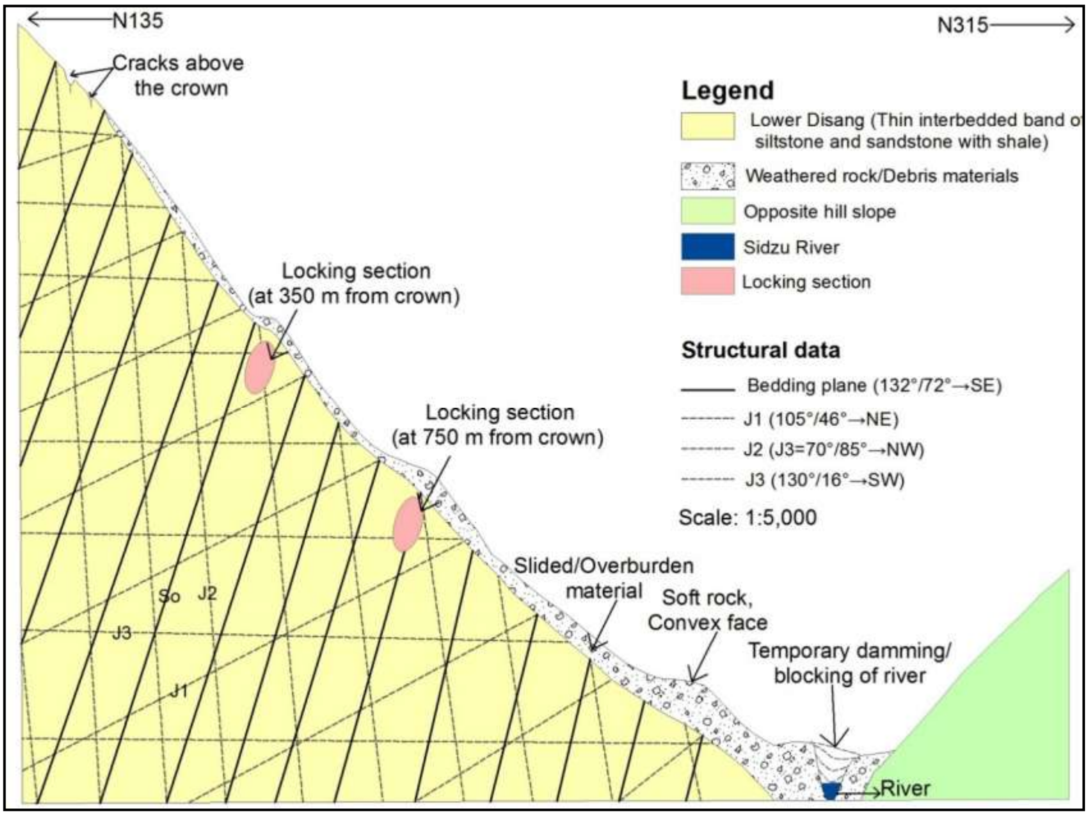


Fig.1: L-section of the slide.

Causative factors of the landslide

Based on preliminary field studies and analysis of the collected data, it has been interpreted that the landslide had occurred due to a combination of factors which are recapitulated below:

1. The affected slope consists of weathered shale of Lower Disang Formation. Overburden thickness ranges from 2-5m.
2. The rocks are highly jointed. Three sets of prominent joints are recorded.
3. The area is highly structurally deformed. Synclinal ridges and anticlinal valleys are present in the area and their axes are closely spaced. As a result of this, slope of the area is quite high. The average slope angle is 40°. This is vulnerable as the slope forming material is weak and thick.
4. The Sidzu River is at young stage at the point of slide. The catchment area is large and has experienced high rainfall prior to sliding. The turbulent flow and rise of water level due to antecedent high rainfall initiated the toe cutting.
5. There was high rainfall in the area for about a week prior to the occurrence of the landslide. This caused saturation of the slope material and the groundwater (pore water) pressure acted to destabilize the slope further.

Recommended remedial measures

1. Avoid further cultivation on the slope, water storage, making artificial canals to restrict instability of the slope. Prolonged water seepage can weaken the slope.
2. Construction of houses and any livelihood is not recommended in the slope. Settlements can be made around the ridges.
3. Subsidence and cracks in the ground along the slope if noticed should immediately be informed to the local administration.

Photographs

Fig 2: View of the Kikruma slide from Chakhabama side.

Fig3: Photograph showing the remnant part of artificial dam on the Sidzu River.

Fig 4: Photograph of the toe of the slide.

Fig 5: Photograph showing slided material deposition along the downstream of the river.

Fig 6: Photograph taken from the crown of the slide showing the scarp faces on the left flank.

Fig 7: The run out material deposited over river terrace (paddy cultivation) causing the change in river course.

Fig 8: Formation of longitudinal cracks along the road due to subsidence caused by toe erosion**.**

Fig 9: Highly sheared, jointed, partly metamorphosed and folded rocks of Lower Disang.

Fig 10: A team from GSI, SU: M&N, Dimapur along with Kikruma Village council members.

42-Points Geoparametric datasheet

1	Slide	NAG/PHEK/83K/2/2018
2	State	Nagaland
3	District	Affected area is in both Phek and Kohima District. Sidzu River defines the district boundary.
4	Toposheet	83K/02
5	Name of the slide	Kikruma Landslide
6	NH/SH/Locality	NH-29, on the west slope of North Kikruma
7	Latitude	25º36’15.5”N
8	Longitude	94º13’19.5”E
9	Length	1200 m
10	Width	600 m
11	Height	≈470m
12	Area	720,000sq m
13	Depth	≈ 6 m
14	Volume	4,320,000 cubic m (approx)
15	Run out distance	80 m
16	Type of material	Rock fragments, debris and soil
17	Type of movement	Slide
18	Rate of movement	Rapid
19	Activity	Active
20	Distribution	Retrogressive
21	Style	Multiple
22	Failure mechanism	Deep translational failure
23	History	Reactivated on 29.07.2018
24	Geomorphology	The slide falls on a moderately dissected slope of the hill.
25	Geology	Black splintery shale and grey phyllite shale of Disang Formation.
26	Structure	So: 032°/72°SE, i) J1=105°/46°→NE, ii) J_2=130°/16°→SW, iii) J_3=70°/85°→NW.
27	Landuse/landcover	Thick vegetation.
28	Hydrological condition	Wet
29	Triggering factor	Rainfall.
30	Death of persons	Nil
31	People affected	Nil
32	Livestock loss	Nil
33	Communication	NH-29 road damaged
34	Infrastructure	NH-29 road damaged, abutment of the bridge partially damaged.
35	Agriculture/ Forest/Barren	Forest.
36	Geoscientific causes	Stated above
37	Remedial measures	Stated above
8	Remarks, if any	Stated above
39	Photos, sketch of the plain and section of the slide	Given above
40	Alert categorization	The slide falls under Category I
41	Summary	-
42	Pdf	-