Highly Damaging Small Landslides of North East India

C. D. Singh and Pankaj Kumar

Abstract

Many areas of North East part of India are prone to landslides due to their complex geological, geomorphological and tectonic settings and growing anthropogenic activities. Increasing incidences of landslide in the recent times in inhabited areas is a matter of grave concern to the society.

Areas of north east India witness a number of landslides during monsoon every year. These landslide have been divided into large and small landslides on the basis of their width. The large landslides in the region affect the normal life by causing blockade of roads and highways and damaging multitudes of properties. However, the small landslides in inhabited areas have a direct impact on society by causing damage to life and property.

The present paper deals with the study on the impact assessment of large and small landslides. The emphasis is laid on understanding the causes and mechanism of failure of small landslides of the region.

Introduction

Landslides are localized processes, which normally don't happen with different frequencies and magnitude at the same location. But for most type of landslides, once the movement has occurred the slope conditions are changed and repetition of a similar event in same location is not likely to happen (Van Westen, 2006). It is very difficult to obtain landslide inventory maps that are complete both with respect to the area covered and to the time period investigated (Isben and Brunsden, 1996). Even when such a map exists it seldom gives adequate information on the type and characteristics of slope failure.

Many parts of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram and Nagaland, the north eastern states of India, are prone to landslides owing to their complex geological, geomorphological and tectonic settings. The region has witnessed innumerable number of landslides of different dimensions in the past. During the last 5-6 years, the region has experienced damage to property, loss of life and road blockade hindering supply due to landslide thus attracting the attention of the media.

The landslides can be classified into large/ major and small/minor landslides based on the breadth of the slide. The breadth of a slide is not affected by other factors but length and height of the slide are controlled by slope, materials involved and viscosity of the moving mass. After seeing the available landslide data of northeastern India for the last five to six years a line of demarcation between large and small landslides is made at 15m width of the landslide. Surprisingly, many of the small landslides of the considered cases caused lot of casualties whereas, it is not so in the case of large landslides. The large landslides damaged structures and blocked the communication routes but have not caused any casualties.

This paper deals with the impact assessment of large and small landslides and lay stress on understanding the causes & mechanism

Geological Survey of India, NER, Shillong

of failure for small landslide and the recommendations for selecting suitable sites in hilly terrain. The paper mainly deals with the landslides that cause inconvenience to the society.

Impact of large landslides

Among the large landslides of recent past, worth mentioning are Mao Songsong, Sajouba, Sonapur, Umtang, Zubza and Rengtekawn landslides. The impact assessment of these landslides, their location, dimension and year of occurrence are given in Table 1.

Table 1: Impacts of large landslides along with location, dimension and year of occurrence

Name of landslide	Location	Dimension	Year of occurrence	Casualties/ Damages/ Inconvenience
Niti Vihar slide (Somnath, 2008)	Near Banquet hall, Niti Vihar, Itanagar, Popumpare district, Arunachal pradesh	L=50m B=25m H =42m	June, 2008	1 person died
Abotani Vihar slide (Somnath, 2008)	Abotani Vihar, Itanagar, Popumpare district, Arunachal pradesh	L=50m B=30m H =40m	June, 2008	1 person died
Namkaolang slide (Singh, 2008)	Near Namkaolang village, Tamenglong Khongsang road, Tamenglong district, Manipur.	L =20 m B =25m H =15m	June, 2008	2 days road blockade
Shajouba landslide (Singh, 2007 B)	Shajouba village, Near Tadubi, Senapati district, Manipur, (State Highway)	Length = 350m Breadth=300m Height = 80m	September, 2007	Blocked Tadubi Ukhrul road, damaged 48 houses
Lokchao slide (Singh, 2007C)	Near Lokchao village, Imphal-Moreh road, Chandel district, Manipur. (NH-39)	Length=10m Breadth=30m Height= 6m	Sep., 2007	5 days road blockade
145.8 km landslide (Kumar & Sawaiyan, 2007)	Near Sonapur village, Jaintia hills district, Meghalaya. (NH-44)	Length = 200m Breadth=50m Height = 150m	September, 2007	7 days road blockade
Tongseng landslide (Kumar & Sawaiyan, 2007)	Near Tongseng village, Jaintia hills district, Meghalaya (NH-44)	Length = 80 m Breadth= 20 m Height = 50 m	July, 2007	Blocked NH-44 for more than 6 hrs.
Sonapur landslide (Rao, 2007)	Near Sonapur village, Jaintia Hills district, Meghalaya, (NH-44)	Length = 870m Breadth=220m Height = 400m	Started in June, 1998 Aug. & Sep, 2000 June, 2001 July, 2004	2 months blockade 22 days blockade 10 days blockade 11 days blockade
Zubja landslide (Am,eta et.al, 2005)	Near Lalmati, Kohima district, Nagaland (NH-39)	Length = 100m Breadth=540m Height = 80m	Started around 1985, Still active 2007)	Frequent blockade of road
Mao Songsong landslide (Singh,2006)	Mao Songsong village, Senapati district, Manipur (NH-39)	Length = 800m Breadth=300m Height = 500m	July, 2004	5 roads and 87 houses were damaged
Umtang landslide (Roychoudhury, et.al. 2004)	Umtang village, East Khasi Hills district, Meghalaya	Length = 100m Breadth=100m Height = 85m	2003	Damaged the cultivated land
Zobawk landslide (Kumar, 2007)	Near Zobawk, Lunglei district, Mizoram (NH-54)	Length = 150 m Breadth= 60 m Height = 80 m	2003	NH-54 washed out, blocked for many days
Rengtekawn landslide (Singh, 2002)	Rengtekawn, Kolasib district, Mizoram (NH-54)	Length = 85 m Breadth=120m Height = 70m	2001	Road blockade

Impact of small landslides

Every year, northeast India witnesses a number of small landslides during monsoon. The impact assessment of some of the important small landslides is presented in Table 2.

Most of the small landslides occur mainly in inhabited areas and the impact of these landslides is immense in terms of loss of life and damage to property. The others which, occur along the highways, away from the populated areas cause only blockade of roads impending the supply.

Table 2: Impacts of small landslides along with location, dimension and year of occurrence

Name of landslide	Location	Dimension	Year of occurrence	Casualties/ Damages/ Inconvenience
Vivek Vihar slide (Somnath, 2008)	Near Homeopathic hospital, Itanagar, Popumpare district, Arunachal pradesh	L=15m, B=15m H =12m	June, 2008	1 person died
Shiv Mandir slide (Somnath, 2008)	Shiv Mandir, Dree ground, Itanagar, Popumpare district, Arunachal pradesh	L=30m B=15m H =25m	June, 2008	1 person died
Tabanglong slide (Singh, 2008)	Near Tabanglong village, Tamenglong Khongsang road, Tamenglong district, Manipur.	L =8 m B =10m H =6m	June, 2008	Few hours road blockade
Nongrimba slide1 (Singh, 2007 A)	Nongrimba, Shillong, East Khasi Hills district, Meghalaya	L=6m B=10m H=4m	Sep., 2007	3 persons died, 1 house damaged
Noonmati slide (Singh et.al. 2007)	Noonmati, Guwahati, Kamrup district, Assam	L=12m B=6m H =10m	Sep., 2007	3 persons died, 1 house damaged
Nongrimba slide (Singh, 2007)	Nongrimba, Shillong, East Khasi Hills district, Meghalaya	L=7m B=3m H =6m	Aug. 2007	1 person died
Slide in Lunglei town (Kumar & Sawaiyan, 2008)	Lunglei town, Lunglei district, Mizoram. (NH-54)	L=15m B=12m H =12m	April, 2007	Few hours road blockade
Rishipara slide (Singh & Sawaiyan, 2007)	Rishipara, Tura town, Tura district, Meghalaya	L=50m B=10m H =40m	July, 2007	9 persons died
Alongmenward slide (Singh, 2005)	Mokokchung town, Mokokchung district, Nagaland	L=12m B=15m H =20m	May, 2005	6 persons died, 2 houses damaged
Aongza slide (Singh, 2005)	Mokokchung town, Mokokchung district, Nagaland	L=5m B=2m H =4m	May, 2005	2 persons died, 1 house damaged
Tongdentsuyong slide (Singh, 2005)	Mokokchung town, Mokokchung district, Nagaland	L=60m B=10m H =50m	May, 2005	4 persons died, 3 houses damaged
Kamakhya slide (Singh & Hazra, 2004)	Nearby Ganesh Mandir, Kamakhya, Guwahati, Kamrup district, Assam	L= 5 m B= 4 m H = 4 m	July, 2004	1 person died, 1 house damaged
Durga Sarobar slide (Singh & Hazra, 2004)	Durgasarobar, Guwahati, Kamrup district, Assam	L= 40 m B= 15m H= 30 m	July, 2004	5 persons died, 6 houses damaged
Durga Sarobar slide (Singh & Hazra, 2004)	Fatasil Ambari, Guwahati, Kamrup district, Assam	L= 5m B= 3m H = 4 m	July, 2004	3 persons died
Kalapahar slide (Raju & Mazumdar, 1999)	Kalapahar, Guwahati, Kamrup district, Assam	Boulder size-5mx4mx3m	July, 1999	11 persons died

L = Length, B = breadth, H = Height

Causes of small landslides

The most commonly observed causations of small landslides of this region are:

1. The unscientific and unplanned cutting of slope.
2. Lack of understanding about the slope stability and properties of slope forming material.
3. Poor maintenance or improper training of drainage.

The causes and type of failures of the different small landslides of the region are given in Table 3. The slope forming materials and type of the houses damaged are also summarised in the table.

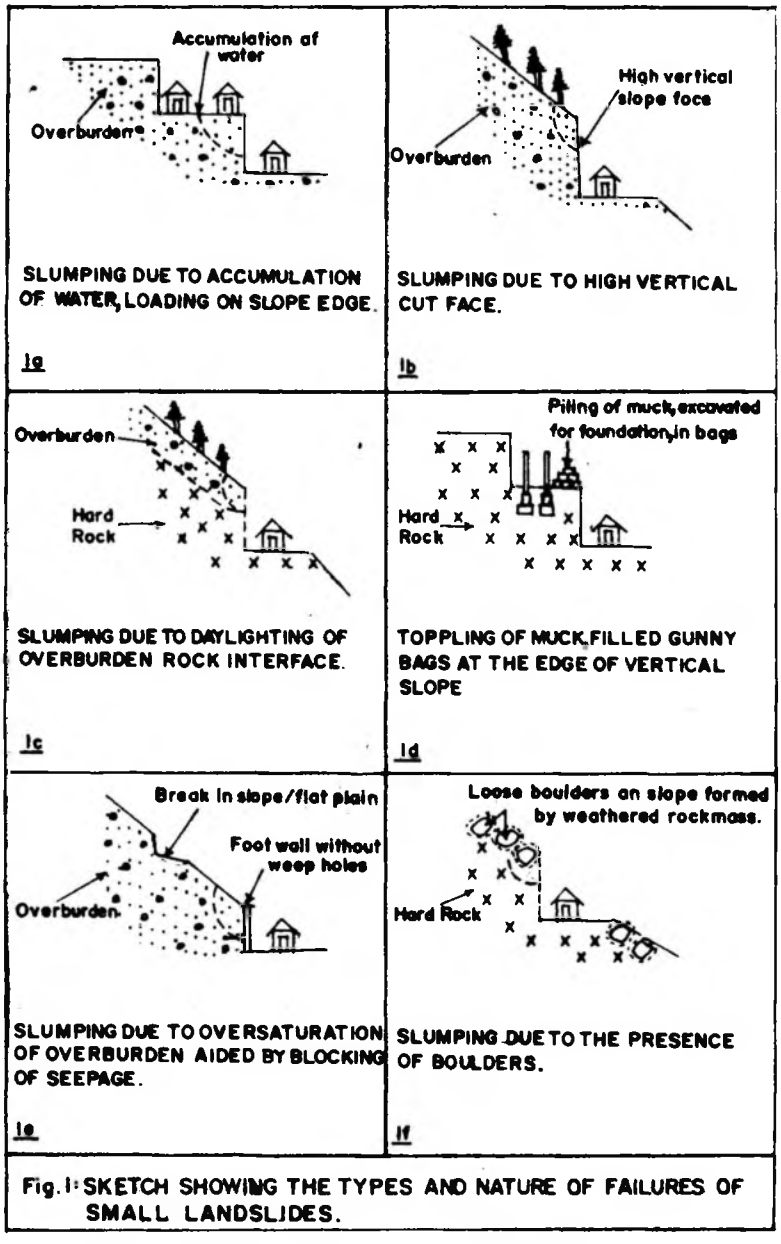

Fig. 1. Depicts the commonly occurring types and nature of failure of small landslides

Table 3: Causes and failure type of small landslide along with the material involved

Name of landslide	Location	Materials involved	Type of house damaged	Causes for failure	Type of failure (from Fig. 1)
Vivek Vihar slide	Near Homeopathic hospital, Itanagar, Popumpare district, Arunachal pradesh	Overbur -den	Hutment	Toe removal, high vertical face, soft material	1b
Shiv Mandir slide	Shiv Mandir, Dree ground, Itanagar, Popumpare district, Arunachal pradesh	Overbur-den	Hutment	Toe removal, high vertical face, soft material	1b
Tabanglong slide	Near Tabanglong village, Tamenglong Khongsang road, Tamenglong district, Manipur.	Overbur-den	-	Toe removal by road cutting, high vertical face exposed	
Nongrimba slide 1	Nongrimba, Shillong, East Khasi Hills district, Meghalaya	Overbur-den	Hutment	Lack of drainage, weight on the edge	1a
Noonmati slide	Noonmati, Guwahati, Kamrup district, Assam	Overbur-den	Assam type	Presence of recharge zone, toe wall without weep holes	1e
Nongrimba slide	Nongrimba, Shillong, East Khasi Hills district, Meghalaya	Overbur-den	Assam type	Lack of drainage, weight on the edge	1a
Slide in Lunglei town	Lunglei town, Lunglei district, Mizoram. (NH-54)	Siltstone and shale	-	Steep slope, wedge failure	-
Rishipara slide	Rishipara, Tura town, Tura district, Meghalaya	Muck in bags	Hutment	Negligence in stocking muck filled bags at the slope edge.	1d
Alongmen -ward slide	Mokokchung town, Mokokchung district, Nagaland	Overbur-den	Assam type	Blocking of nala, construction of wall across the nala.	1e
Aongza slide	Mokokchung town, Mokokchung district, Nagaland	Overbur-den	Hutment	High vertical face, soft material, lack of drainage.	1b
Tongdent-suyong slide	Mokokchung town, Mokokchung district, Nagaland	Overbur-den	Assam type	Old slide zone, slope farming along the nala, blocking of nala.	-
Kamakhya slide	Nearby Ganesh Mandir, Kamakhya, Guwahati, Kamrup district, Assam	Overbur-den	Assam type	Lack of drainage	1e
Durga Sarobar slide	Durgasarobar, Guwahati, Kamrup district, Assam	Overbur-den	Assam type	Toe removal	1f
Fatasil Ambari slide	Fatasil Ambari, Guwahati, Kamrup district, Assam	Overbur-den	Assam type	Hard rock and overburden contact is parallel to hill slope.	1c
Kalapahar slide	Kalapahar, Guwahati, Kamrup district, Assam	Rock	Assam type	Falling of hanging boulder/ block of rock	1f

Discussions

The degree of damages of a landslide depends on the location and the rate of movement of the slide. The relation between the rate of movement of slide and concentration of population and possible impact is shown in Table 4.

Fortunately, during the last 5-6 years, north eastern region does not experience any rapid moving landslide in either highly populated or thinly populated areas. Mao Songsong and Shajouba landslides (Table 1) do not show any casualty despite its considerable dimension. However, and number of houses have been damaged, because of the slow rate of movement. The rapidly moving Umtang landslide and Sonapur landslide damaged the cultivated land and blocked the National Highway for many days respectively. In general, the large landslides of the study area cause inconveniences by cutting off civil and

Table 4: Probable impact along with the rate of movement and location of slide

Location	Large Landslide		Small Landslide	
	Rapid moving large landslide	Slow moving large landslide	Rapid moving small landslide	Slow moving small landslide
Thickly populated area	Highly disastrous	Highly hazardous	Disastrous	Hazardous
Thinly populated area	Disastrous	Hazardous	Disastrous/ Hazardous	May be hazardous
Communication route	Major inconve- nience, may block roads for many days	Inconvenience, partial blockade of roads	May cause inconvenience	May cause inconvenience
Remote area, no settlement and no commu- nication route	No societal effect, if of stream damming is not involved. Damage agri. and forest land.	No societal effect, if not damming. Damage agri. and forest land.	No effect	No effect

other supply lines apart from damaging structures. However, in all these large landslides casualties are not reported.

Most of the small landslides are rapidly moving landslides and occurr in the inhabited areas. If the landslide size is very small, the warning signatures are not prominent and they are not long lasting. The small landslides give a direct impact by taking a toll on human lives and damaging properties.

Very shallow rotational failure within the overburden is the predominant type of failure seen in these small landslides.

Human interference in the form of blocking and improper training of drainage, unscientific and unplanned cutting of slope for space, exposing a very high vertical cut slope, construction of structures etc. are the important causal factors for small landslides.

All the damaged houses are either very small & light Assam type or hutment. In most of the cases, damage is due to the sliding of upslope material on it.

Considering the dimensions and nature of the slides, size and type of the houses damaged and nature of settlement, the landslides are of very localised type.

Conclusion

The small landslides in the area are very localized in nature and small in size. The damaged structure mostly belongs to the people from economically weaker strata of the society. Considering the economic condition of the people and the nature and size of the structures they live in, advising for scientific cutting of slope by applying safety factors. wouldn't be of much help.

The best option would be to generate awareness among the people by organizing programs that explain the dangers and damages of the small landslides, their causes, remedial or preventive measures in the simplest and generalized way. Some of the pre-construction and post-construction preventive measures applicable in north eastern region are explain below:

1. Safe area is to be identified for construction.
2. The natural drainage should not be disturbed or blocked on the slope. Water should not be allowed to accumulate or percolate on the slope or nearby the constructed structures.
3. Avoid the up slopes where boulders are exposed.
4. The daylight of possible slip plane (Fig. 1c), must be avoided as far as possible.
5. Exposing a very high vertical face be avoided (Fig. 1b).
6. Pillars or piles tied to bedrocks should be used for construction without, as far as possible, disturbing the natural slope.
7. During monsoon, people should watch out for any distressed zone in the upslope, if there is any, better to move out of that place.

8. Construction of civil structure and dwellings should be regulated.

Acknowledgement

The authors are grateful to Shri B.K. Mohanty, Deputy Director General, GSI, NER, Shillong for giving permission to publish the paper The authors express their sincere gratitude to Shri E. Ramalingam, Director, LHZP, GSI, for his valuable guidance and indispensable inputs to this work. The authors highly acknowledge Shri E. Balasubramanian and Shri Inder Singh (Directors), P.V.S. Rawat and Maneesh Khaer (Geologist Seniors) for scrutinizing the paper. The authors acknowledge the help from Shri Kharswandi in drawing the figures.

References

Ameta , S. S., Mukherjee, J., and Gupta, S .K. (2005) : Landslide inventory, North Eastern Region. Unpublished GSI Report.

Ghosh, R. N. and Singh, R. J. (2001) : A report on the slope stability study around Serchhip Hmar Veng, District Serchhip, Mizoram. Unpublished GSI report (F.S.2000 – 2001).

Ibsen, M. and Brunsden, D. (1996) : The nature , use and problems of historical archives for the temporal occurrence of landslide with specific reference to the south coast of Britain, Ventnor, Isle of Wight, Geomorphology 15, 241-258.

Kumar, P. (2007) : Landslide hazard zonation and slope stability studies around Lunglei area, Mizoram. Unpublished GSI report (F. S. 2005-06).

Kumar, P. & Sawaiyan, S. C. (2007) : A note on the occurrence of landslides in Jaintia Hills district, Meghalaya. Unpublished GSI geotechnical note on landslide.

Kumar, P. and Sawaiyan, S.C. (2008) : Meso scale landslide hazard zonation and slope stability studies around Lunglei town, Mizoram. Unpublished GSI report (F. S. 2006-07).

Raju, M. and Mazumdar, K. (1999) : A Geotechnical report on the landslide occurred at Kalapahar of Guwahati, Kamrup District, Assam. Unpublished GSI geotechnical note on landslide.

Raju, M., Sharma, V. K., Khullar, V. K., Chore, S. A. and Khan, R. (1999) : A Comprehensive report on landslide hazard zonation of south Mizoram, Unpublished GSI report (F. S. 1997-98).

Rao, K. S. (2007) : Interim report on site specific studies of Sonapur landslide. Unpublished GSI report F. S. 2004 – 05.

Roychoudhury, J., Singh, C. D. and Hazra, D. (2004) : A note on the occurrence of landslide at Umtang village, East Khasi Hills District, Meghalaya. Unpublished GSI geotechnical note on landslide.

Singh, C .D. (2005) : A note on , Mokokchung landslide of May, 2005, Mokokchung District, Nagaland. Unpublished GSI geotechnical note on landslide.

Singh, C .D. (2006) : A report on Mao Song Song landslide, 214 km , NH – 3 , Senapati District, Manipur. Unpublished GSI report (F .S . 2003 – 04).

Singh, C. .D (2007 A) : A note on the landslide occurrences on Nongrimba area, Shillong, East Khasi Hills District, Meghalaya. Unpublished GSI geotechnical note on landslide.

Singh, C .D (2007 B) : A note on the landslide occurrences in Upper Shajouba village, Senapati district, Manipur. Unpublished GSI geotechnical note on landslide.

Singh, C .D (2007 C) : A note on the landslide occurrences inImphal-Moreh section of NH-39, Chandel district, Manipur. Unpublished GSI geotechnical note on landslide.

Singh, C.D. (2008) : A note on post disaster studies of landslides along Tamenglong Khongsang road, Tamenglong district, Manipur. Unpublished GSI geotechnical note on landslide.

Singh, C .D., Bora, A. and Sharma, P. K. (2007): A note on September 16, 2007 landslide at Noonmati area of Guwahati, Kamrup District, Assam. Unpublished GSI geotechnical note on landslide.

Singh, C .D. and Hazra, D. (2004) : A note on the July 2007 landslide around Guwahati, Assam , Unpublished GSI note.

Singh, C. D. and Sawaiyan , S . C. (2007) : A note on July 27, 2007 Tura landslide, West Garo Hills District, Meghalaya. Unpublished GSI geotechnical note on landslide.

Singh, R . J. (2002) : Report on macro level Landslide Hazard Zonation in part of Aizawl District, Mizoram. Unpublished GSI report (F.S. 2001-02).

Somnath. (2008) : June 14, 2008 landslide of Itanagar, Arunachal Pradesh. Unpublished GSI geotechnical note on landslide.

Van Westen, C. J., Van Asch, T. W. J. and Soeters,. R. (2006) : Landslide Hazard and Risk Zonation –why is it still so difficult? Bull. Eng. Geol. Env., vol.-65, pp 167-184.