Rainfall, A Major Cause for Rockfall Hazard along the Roadways, Highways and Railways on Hilly Terrains in India

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Abstract

Rock-falls are well-known phenomena, all over the world and every part of the hilly and mountainous regions suffered from rock-fall. Rockfall is a type of landslide in which a single rock or boulder or a small groups of independently moving rocks become dislodged from an exposed face or slope and move downward by means of some combination of sliding, rolling, bouncing or free-fall under the action of gravity. If the rock-falls occur in a remote area, they will be of scientific interest only. However, if they occur, along highways, roadways and railways then they are more than a spectacular natural process. Moreover depending upon where and when rock-falls occur, they have potentially serious consequences. The major cause of rockfall is heavy rainfall, though there are also other causes but rainfall shares the majority of the percentage directly or indirectly. There are too many reported rock-falls from India that have triggered exclusively by rainfall. Landslide along Jammu-Srinagar National Highway, caused by heavy rainfalls, triggered rock-fall at Bailey bridge across Panthal Nala and completely destroyed the bridge. The Malpa rock-fall tragedy of 18th August 1998 instantly killed 220 people and wiped out the entire village of Malpa on the right bank of river Kali with the tracking route, in the Kumaun Himalaya of the state of Uttarakhand. The most recent devastating accident related to rockfall along the railway occurred on 19th July 2012, when Chhatrapati Shivaji Terminus bound Kasara local, derailed from the tracks due to boulder on the track after the minor landslide caused by heavy rainfall for almost a week and was rammed by speeding Vaidarbha Express causing one death and 14 others injured.

Keywords

Rainfall • Rock-fall • Hazard

87.1 Introduction

Rockfall is a sub-type of the phenomena related to as landslide in which a single rock or boulder or a small groups of independently moving rocks become dislodged from an exposed face or slope and move downward by means of some combination of sliding, rolling, bouncing or free-fall under the action of gravity (Varnes 1978). In some cases rockfall refers to quantitative measure, describing small phenomena ranging from few m^3 up to 10,000 m^3 events,

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whereas rockslide is used to describe more than 1,00,000 m^3 and rock-avalanches can reach several millions m^3 (Dussauge-Peisser et al. 2002).

Keefer (2002) studied 40 worldwide historical landslides induced by earthquakes and found rockfalls to be the most abundant of all type of landslides, along with disrupted soil slides and rockslides. According to World Bank data, 95 % of the deaths occurred in developing and under-developing countries due to natural disasters i.e. earthquakes, landslides, floods and rock-falls etc. (Kremier and Arnould 2000).

87.2 Causes of Rockfalls in India

There are 14 causes of rockfall. Out of 14 causes, 6 are directly related to water, namely rain, freeze-thaw, snowmelt, channeled runoff, differential erosion, and springs and seeps. Also growth of tree roots in cracks is indirectly related to rainfall that can open the cracks and loosen the rock blocks. These seven causes of rock-fall together account for 68 % of the total falls (Hoek and Bray 1981) (Fig. 87.1).

India, due to its unique climatic conditions and its closeness to geodynamical active areas, has always been vulnerable to large number of landslides due to rainfall. The Himalayas, including Jammu and Kashmir, Himachal Pradesh, Gharwal, Kumaon, Sikkim, the Darjeeling Hills, Arunachal, and the Northeast hill, are where the rate of incidence of landslides/rock-falls range from high to very high whereas the Western Ghat, Nilgris hills have high to moderate landslides/rock-falls incidences and the Eastern Ghats, Vindhyan ranges show low landslides/rock-falls incidences (Kumar et al. 2008).

About 90 % of the landslides/rock-falls takes place during monsoon or winter rains in the Northwestern Himalayas. Moreover rains play a vital role in triggering most of the landslides in the Himalayan region. From south to north, the Indian Himalayas can be divided into different climatic zones, i.e. the tropical, sub-tropical, sub-temperate, semi-arid and arid zones. Precipitation also varies across these climatic zones. Monsoon precipitation is largely received south of the Higher Himalayas as compare to north Himalayas. Snow brought by winter rains at higher altitudes is more pronounced in the western region as compare to eastern region of Himalayas.

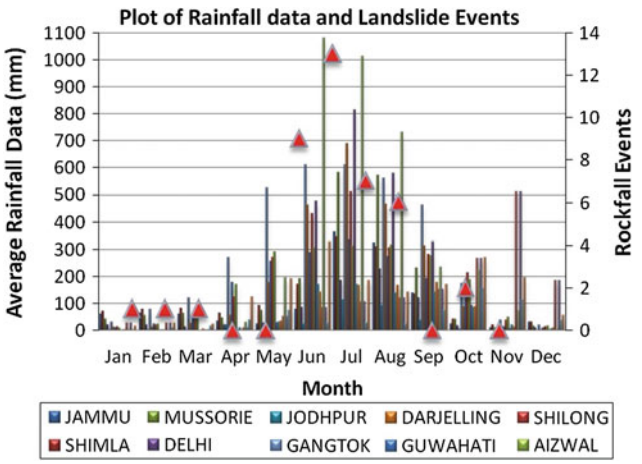

Fig. 87.2 Rainfall distributions for different states of India since 1901–2010. Also showing events of landslides/rock-falls (*Source* www.imd.gov.in)

The rainfall data plotted against the landslides/rock-falls events since 1901–2010 indicates that most of the landslides/rock-falls are associated to monsoon time during June-September (Fig. 87.2). However some of the landslides/rock-falls do occurs in the month of Dec–March (Table 87.1). Also Table 87.1 demonstrates some notable landslides/rock-falls events happened in the past in India.

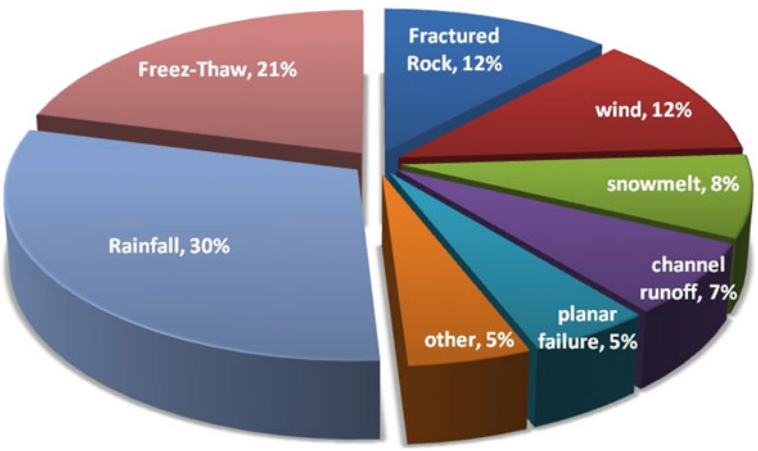

Fig. 87.1 Pie chart showing causes of rock-falls (modified after Hoek and Bray 1981)

Table 87.1 Summary of landslide and rock-fall events occurred in India (*Sources* GSI reports and newspaper)

Date	Location	Description
18th Sep. 1880	Sher ka Danda Hill, Nainital	Killed 143 people, closes route for over a week
14th Nov. 1893	Gona Slide of Birehi valley, Garhwal	Damming Birehi Ganges stream
Jul-67	Along Jammu-Srinagar N.H. (1A), J&K	Bailey Bridge across the Panthal Nala collapsed
20th July 1970	Hemlet of Belakuchi. Garhwal	Landslide: Killing 55 persons and flooding downstream up to the town of Srinagar
1st Aug. 1978	Naina Devi	143 structures, portion of the road, steps of the temple carried down slope over a distance of 150 m
19th Sep. 1989	Kaliasur landslide in Alaknanda valley	Landslide: route block more than a week
June-July 1983	Nashri Landslide, 131 Km from Jammu	Road Blockade lasting for 13 days
1st July 1993	Itanagar, Arunachal Pradesh	Landslide: 25 lives were lost
5th Aug. 1993	Kalimpong, West Bengal	Landslide: 40 lives were lost
18th Aug. 1998	43 km north of Dharchula, Malpa	221 people died
19th Aug. 1998	Okhimath tehsil, Haridwar-Badrinath road	101 life's perished, loss of valuable properties
01st Nov. 2001	Amboori Landslide, Kerala	Landslide: caused blockage of the route
23rd June 2003	Vaibhavwadi Train Crash, Sindhudrug	52 people killed in crash and over 1,000 injured
24th Sept. 2003	Bhagirathi valley, Dist. Uttarkashi	Damage to residential area, infrastructures
16th June 2004	Matsyagandha Express Train Crash	14 people killed and 62 injured
23rd Jan. 2008	Near Nathpa Jhakri Dam, H.P	Two persons were killed and one got injured
17th Mar. 2008	Nehru Kund Landslide, Kullu, H.P	5–6 persons. Size of falling block $\sim$400 m^3
18th July 2008	Saptashrungi Temple, Nashik, Maharashtra	Some damage caused to Temple. No casualty
11th June 2010	Haati Surey (NH 31A, Siliguri-Gangtok)	Rock-fall closes route for over a week
18th Sep. 2011	Jorethang-Rishi section (along River Rangit)	One person killed, one car damaged
27th June 2011	Dharasu, Chilyasan	1 child die, NH-108 block for 18 h
28th June 2011	Nalupani along National highway 108	3 cars damage and blockage of the routes
9th July 2011	Thrang	NH-108 closed for 8 h and 200 pilgrims struck
22nd July 2011	Vasuti taal	8 mountaineers died
22nd July 2011	Thrang along National Highway 108	More than 200 vehicles struck
12th Aug. 2011	Sainj	Road block for days, resulted in food scarcity
18th July 2012	Kasara Local Train Crash	One killed, 14 injured
10th June 2013	Devram Chawl, Wadala, Mumbai Maharashtra	People stuck in debris. No casualty reported
16th,17th July 2013	Uttarakhand (Rudrapyarag District Town)	Thousands of Pilgrims, local person buried under debris
25th July 2013	Malshej Ghat along NH-222, Maharashtra	Two men died, one vegetable carrier van trapped and highway blocked for more than a week

87.3 Rainfall and Landslides in India

Indian highways, roadways and railways in mountainous and hilly areas have been experiencing horrific landslide incidences that caused rockfalls. According to Sharda (2007), 15 % of the land area is affected by landslides. Every year during the monsoon period, several region of India is affected by landslides/rock-falls. Landslide along Jammu-Srinagar National Highway in July, 1967, caused by heavy rainfall, triggered rock-fall at Bailey bridge across Panthal Nala and completely destroyed the bridge. The Malpa rock-fall tragedy of 18th August 1998 instantly killed 220 people and wiped-out the entire village of Malpa on the right bank of river Kali with the tracking route, in the Kumaun Himalaya of the state of Uttarakhand.

A few notable examples of the recent rock-falls caused by rainfall are as follows;

The recent most casualty caused by landslide, induced by heavy rainfall, occurred on 16th and 17th June 2013 at Uttarakhand. According to Indian Meteorological Department (IMD), Uttarakhand received rainfall greater than 400 % from normal rainfall. These heavy rainfalls triggered

the landslide and the town of Rambara was totally washed away. Also thousands of pilgrims and local at Kedarnath town were buried under debris or flowed away by the flood caused by heavy rain.

On 25th July 2013, in the western part of India on NH-222 near Malshej Ghat, Maharashtra, rockfall triggered after the preceding day one week heavy rainfall. Giant boulders almost of two truck size, fell on two men, killing them and blocked the highway for almost a week. In a similar situation, rockfall occurred at Wadala area, Mumbai, Maharashtra. The rock-fall destroyed the house and buried it. However no causality was caused. This event too happened after very heavy rainfall.

Heavy rainfall on August 2012 in Uttarkashi was the source of flash flood and landslide that took the life of 31 peoples. Also thousands of pilgrims were trapped there due to wiped out roads. Not only has the Himalayan region suffered from casualties due to rainfall induced landslide but also northeastern part has been the witness of such type of casualties. In June 2012, the landslide triggered by heavy monsoon in Ri-Bhoi district, Meghalaya, blocked the NH-40. Also at the same district, on 26th July 2012, landslide killed two members of the family when the house was buried in the landslide. Rock-fall occurred after 18th September 2011 earthquake in Sikkim caused death to person and damage a car at Baluwakhani area.

Highways and roadways were not only affected by landslides and rockfalls in India, but railways too have history of landslides and rock-falls that caused loss of life's and property as well as economy. The most recent devastating accident related to rock-fall along the railway occurred on 19th July 2012, when Chhatrapati Shivaji Terminus bound Kasara local, derailed from the track due to boulder on the track after the minor landslide and was rammed by speeding Vaidarbha Express causing one death and 14 others injured. This is not only the case of railway accidents due to falling blocks/boulders on the railway tracks but also we have few more in the past viz. Vaibhavwadi train crash in June, 2003 (ExpressIndia 2003) and Karanjadi train crash in June, 2004 (People's Daily 2004).

87.4 Conclusion

The primary concern is to save the lives of the people living and/or travelling in rockfall prone areas. The number of death due to rock-falls is much smaller than the number of people died in stream and river and certainly much smaller than the number of people died in traffic accidents. However one big rockfall in wrong place at a wrong time, could cause dramatically increase in the number of death as describe in this article. At present, rockfall is a new filed in India and it needs more research for handling the problem related to rockfall. Due to this reason we are focusing on learning everything we can about rockfall using laser scanning, computer modeling, and monitoring of slope/cliff faces. Also efforts are being made to develop a relationship between rainfall and triggering mechanisms for rock-falls.

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