

Recent Landslides In Goa - An Overview

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Abstract

The paper presents the characteristics of landslides occurred in the State of Goa during the last three years. The affected areas are Anmod Ghat (NH 4A), NH-17, State Highway connecting Pernem -Morjim- Mapusa, Vasco, Wydongar hillock, Capo Hill and Konkan Railway. Most of the slides are of shallow type and are debris slides. Granite and granite gneiss are the country rocks and they are capped by laterite / lateritic soil. The study reveals that the thickness of overburden is high and the slope is moderate. Principal cause for the slides found to be human interference with the slope for the construction of roads and human settlements ignoring the safety norms. The slides were triggered by heavy rainfall.

Introduction

Landslides are the major geological hazards that affect Goa. In last three years, Goa witnessed major landslides at Decarpolli, Desteiro and Porvorim. Decarpolli landslide claimed 11 lives and Tariwada (Desteiro) slide damaged 48 houses. A slide that occurred on the National Highway 17 near Mandovi Bridge circle at Porvorim near Panaji blocked the road. The hillside slope at Sancoale Railway siding experienced series of slides in the year 1973-74 as a result of cutting at the toe of the hill for installing a railway siding.

The Western Ghat, uplands and coastal region of Goa are highly susceptible to landslides (Fig. 1). Changed land use pattern as a result of rapid development has aggravated the situation. Frequent occurrence of landslides in many parts of Goa necessitated detailed study of landslides both on regional and large scale.

Physiography

Goa with an area of 3,702 km² is bound by latitude 14°53'54" and 15°40'00" N and longitude 73°40'33" and 74°20'13" E. It is located at the foot hills of Sahyadri on the west coast of India and is encompassed by

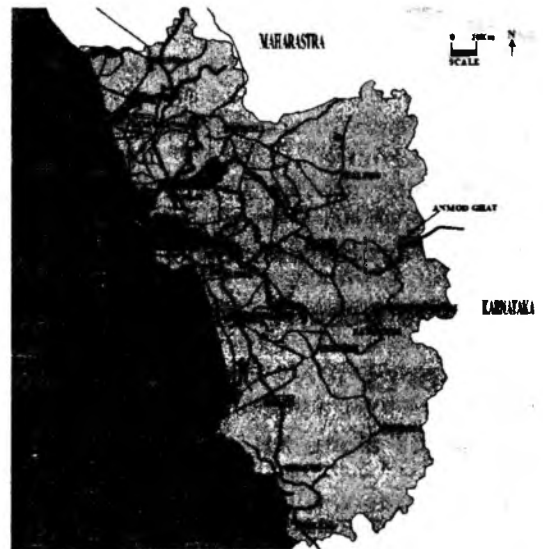


Fig. 1: Map showing some of the landslide locations of Goa.

Karnataka in south and east and Maharashtra in north. Barring the limited plains and intermittent valleys carved out by the rivers, the state is almost on Western Ghats. Physiographically, Goa is divided into four regions from east to west viz., 1. Western Ghat (700-1000 m above msl), 2. Foot hill region of Western Ghat (300 to 700 m) 3. Undulatory terrain (10 to 300 m) and 4. Coastal plains. Goa's main rivers are

Mandovi, Zuari, Tiracol and Chapora. The Mormugao harbour situated at the mouth of the River Zuari is one of the best natural harbours in South Asia.

Geological Setting

Goa is occupied by Goa Group of meta-volcanics and meta-sedimentary assemblages (Archaean to lower Proterozoic), mafic ultra mafic complexes and intrusive granites (Lower Proterozoic), Deccan Traps (Upper Cretaceous to Eocene), laterite (Cainozoic) and beach sand (Quaternary). The Peninsular Gneissic Complex is represented by Tonalite-Trondhjemite-Granodiorite suite of rocks exposed in Anmod Ghat in east and Quepem in central part. The State is extensively covered by a thick mantle of laterite. The region consists of actinolite-quartz schist, chlorite-sericite schist, quartzite, metabasalts, greywacke/arkosic wacke, ferruginous phyllites, siltstone, shale, granite and gneisses of Dharwar Super Group.

Landslide Occurrences

HILL SLOPES

Landslides along NH 4A- Anmod Ghat Section

Twenty two numbers of medium and small slides were recorded in this section. The area comprises of weathered granite gneiss, granite and basic dykes. Thickness of overburden consisting of soil and weathered rock varies from 1 to 5 m. Majority of the slides were found to be shallow debris slides caused mainly by toe cutting of the slope for making roads (photo 1 & 2). The vertical cuts have failed due to heavy rainfall during monsoon.

The debris consist of boulders, rock fragments and colluvial deposits. Length of the slides varies from 10 to 25 m and breadth from 5 to 32 m. During the rainy season, heavy infiltration caused over-saturation of slope material which resulted in increase in



Photo 1. The debris slide on NH-4A Panjim-Ponda road. Retaining wall has to be extended.



Photo 2: The debris slide at km 129 on NH-4A (Panjim- Ponda road).

pore pressure and decrease in shear strength.

UPLAND

Landslide at Porvorim, Betin

A slide occurred on the NH 17 in the hillock just opposite to the Goa Assembly Complex at Porvorim near the Mandovi Bridge circle (photo-3). The debris slide at Betin, Porvorim is due to toe cutting for road widening. The steep hill slope failed during heavy rainfall in monsoon of 2007. The slope has been graded to improve its stability.

Landslide on Valpoy-Chaverde State Highway

The Chaverde slide is a shallow debris slide occurred due to cutting of slope to build



Photo 3: The debris slide at Porvorim on NH-17.

houses and heavy ingress of water into the lateritic soil.



Photo 4: Landslide that occurred near Dicarpole Village, South Goa on 14-07-05.

Dicarpole landslide

This one occurred near Dicarpole Village, South Goa on 14-07-2005 (photo-4). Studies carried out revealed that the country rock is highly weathered quartzo-feldspathic gneiss intruded by pegmatite, quartz vein and numerous dolerite dykes. Foliation in gneiss trends N35°-40°W and dips at 35° towards NE. Factors found responsible for occurrence of the slide were weathering of the rock, increase in unit weight of the slide material due to over-saturation, cutting of the slope for road formation and increase in pore pressure (Dharuman, 2005).

Preventive measures suggested are the stoppage of indiscriminate cutting of hill slopes and stabilizing the existing cuts, provision of contour drains and restoration of vegetal cover etc.

Landslides in Vasco-Da-Gama

The cut slopes in lateritic terrain of Vasco-Da-Gama town failed at several places due to heavy rains in June - July 2007. All were shallow debris slides. The modified slopes slid due to over-saturation of laterite, poor drainage and overloading of the crown i.e. construction of buildings at the edge of the cut slopes. Different slides for which preliminary investigations carried out are as follows:

Jetty Sada, Rumdowado: Foundation of the upper level house constructed at the edge of the vertical slope failed and slid down along with the slope material. The muck flowed into two houses on the path. The house at the upper level and two houses at the lower level are in danger.

Bharat line, Desteiro: The slide is located at lat. 15° 23' 46" N and long. 73° 48' 12" E. The slide area is a small hillock facing the sea and its average elevation from msl is about 25 m. The slope of the lateritic hillock slid in SE direction resulting in partial collapse of a house on the edge and damage to another. The debris moved nearly 30 m from the crown. The crown cracks are observed on the wall and pavement of the houses with both horizontal and vertical displacement. The 30cm thick PCC lining of the vertical slope without any weep holes did not allow the water to drain out causing high pore water pressure and instability of the slope. The vertical slope is unstable. Proper drainage holes are to be provided for the lining.

Merces Waddo: Three apartment buildings were constructed in this area at the hill top by cutting the slope and leveling it. The original slope was steep and the cut slope is nearly vertical. There was a three storied building before the apartments came up. The apartments have blocked two streamlets. Blocking of the streamlets has increased the percolation and pore pressure. This led to minor sliding in lateritic material along these blocked streamlets.

Landslides In Coastal Area

Wydongar slide

The slide at Wydongar hillock is a reactivated retrograde debris slide (photo-5). Length of this slide is 83 m, breadth 75 m and scarp depth is 9 m. The locality is covered by laterite and clay and they failed due to undermining of toe by Chopra River. Besides, cutting at the toe for accommodating the



Photo 5: Debris slide at Wydongar, North Goa.

village at foot hills and modification of the slope for cashew plantation added to the problem. Concentric crown cracks of length 50 m and width 0-15 cm are noticed in the Wydongar hillock (photo-6).

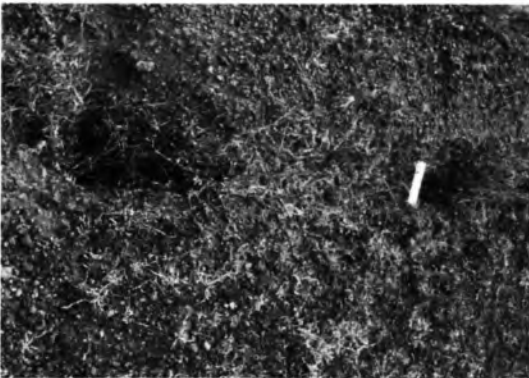


Photo 6: Concentric crown cracks in the Wydongar hillock.

Cabo Hill Slide

Raj Bhavan Building of Goa, situated atop the Cabo Hill (El. 40 m) is over 400 years

old. This NW-SE trending promontory is confined by Mandovi River in North and Zuari River in South. They meet Arabian Sea after flowing southerly. The western and northwestern slopes of this hill adjacent to Raj Bhavan and facing the Arabian Sea has been experiencing continued distress since a few decades. Cracks have developed on the pavements and floor of verandah and extend head-ward retrogressively intercepting the corners of the back portion of the building of Raj Bhavan (*Panduranga et. al. FS 2003-04*).

Tariwada, Vasco

Laterite forms lithology of the area and the slide occurred due to continuous rain for 2-3 days. The landslides at Tariwada (Desteiro) damaged 48 houses.

Landslide Near Railway Route

Konkan Railway, Canacona

A major landslide occurred on 07.08.2007 at 1505 hrs on the eastern slope ($15^{\circ} 01' 11''N$, $74^{\circ} 02' 05''E$) of the NNW-SSE trending hill along the Konkan Railway alignment between Ch. 473.700 km and 473.400 km. The grey, fine to medium grained gneisses with NW-SE trending gneissosity and northerly dip at 60° is exposed at the base and all around the slide area. The rock has four sets of joints, viz., 1. NW/ 60° - 70° SW, 2. N 10° E/ 60° - 70° WNW, 3. N 20° W/ 60° ENE and 4. NW/ 60° NE. The rock is fresh except at the slide area where weathering up to a depth of 2-3 m is observed.

The slide on the slope is a deep, wedge failure cum debris flow. Weathered gneiss and the overburden in nala section failed due to heavy rainfall. Approximately 10, 000 m³ of slid debris with rock moved in S 35° W direction.

Zuari Slide

Hill side slope at Sancoale railway siding experienced series of slides in the year 1973-

74 as a result of cutting at the toe of the hill for installing a railway siding. This slide resulted in heavy damage to standing railway wagons, loading platforms and put in danger the fertilizer plant located on top of the hillock.

Dudhsagar Slide

A major landslide occurred on 6th September 2004, on the northern flank of railway cutting between Caranzol and Dudhsagar Railway Stations at 37/11.5 km of Londa-Vasco line.

Coarse grained grey granite capped by lateritic soil forms the rock type of the area. The top soil supports moderate growth of vegetation. Sliding of the rock mass is mainly due to unfavourable geological condition and heavy rainfall. Cutting of the hillock for a depth of more than 24 m has exposed the steeply dipping joint planes at the crown and allowed water to percolate thereby exerting pressure. Added to this, the rainfall has induced excessive pore pressure on the slope forming material. As a result, toppling and planar failure had occurred. Wedge failure is also seen at the eastern part of the slide. (*Panduranga and Dharuman, FS 2004-05*).

Discussions and Conclusions

The study reveals that the preparatory factors for the slides are the favourable terrain, highly weathered rock mass, thick overburden, cutting of slope for road formation and human settlements etc. Rainfall extending for 4 months from May to August is the main triggering factor for all the landslides in Goa. Not only the average rainfall but, intensity of the rainfall is also high. Along sea shore, the slides are triggered by wave action. Cutting of the hill slopes without providing retaining walls and drainage has created favourable condition for slides. The factors which cause the slides in Goa and their remedial measures are as follows:

1. Cut slope angle and height plays a major role in all the slides. The slope becomes vulnerable when the cut slope

angle is $70^\circ - 90^\circ$.

2. The landslides are noticed where the lithology is laterite, weathered granite and gneiss. Because of deep weathering, granite and gneiss lose their strength and become more susceptible to landslides.
3. The depth of weathering is very high at 15-20 m as noticed in most part of the State. It is due to warm and humid climate and high rainfall.
4. All the slides are shallow with <2 m depth and are mainly debris slides.
5. The discontinuities in rock mass play an important role in causing planar and wedge failures.
6. Some reactivated old slides are noticed on NH - 4A near Ponda. In these slides, inadequate remedial measures have caused their reactivation.
7. Blocked drainage is observed in 60% of locations of the slides. Run-off water from the hill may be channelised by making contour drains, catch water drains and chute drains. Pore pressure in the overburden may be released by providing drainage holes and weep holes.
8. Various techniques like landslide hazard zonation to identify and avoid the risky zones, cutting of slopes with safe angles, protection of the cut faces, providing drainage, designing the structure to suite the terrain etc. are available in this field. The loss caused by the slides can be avoided by adopting planned development of the hill slopes through scientific methods.

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