InSAR Monitoring of High Risk Geohazard Areas using RADARSAT

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Abstract

In this paper, we report on the results of InSAR monitoring of several high-risk Geohazards- Landslides, Earthquakes and Volcanoes- areas using RADARSAT 1&2 images. InSAR techniques are increasingly being used for geohazard assessment. Our research has shown that differential InSAR and coherent target monitoring techniques with installed corner reflectors are used to monitor landslide activity along strategic transportation and energy corridors in Canada and China and Latin America. We used InSAR to monitor landslide motion triggered by permafrost melt in the Canadian arctic, debris flows, rock avalanche, and deep-seated landslides in mountainous areas in Canada China and Venezuela. RADARSAT InSAR images have also been used to monitor seismically active areas in Canada, as well as volcanic areas in Japan. The results of these case studies will provide guidelines for the uses on advanced SAR techniques for disaster mitigation related to geohazards

Our planned RADARSAT Constellation will also provide the rapid revisit for frequent monitoring of high risk geohazards sites. RADARSAT Constellation is a low cost, high revisit mission scheduled to be launched in 2013. The Constellation will provide daily global coverage at 50m resolution. The satellites are equally spaced in same orbit to provide 2 to 4-day InSAR monitoring. In addition, its 3 meter resolution, dual polarization capability will support SAR mapping programs in agriculture, forestry, mapping and disaster monitoring.

Avalanche Threat Evaluation and Mitigation Strategy in Western Himalayan Region, India

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Abstract

The destructive potential of avalanches in Western Himalayan region is unparallel in the world. A number of waves of avalanches in a season paralyse movement completely in some regions. The avalanche season in western Himalaya is the result of interaction of winter weather systems with highest mountain ranges of the world, as they move from west-southwest to east-northeast direction. The typical orientations of Himalayan ranges produce a distinguishing character of avalanching in western Himalaya. When these systems manifest as induced low with deep troughs up to 500 hpa, copious feed of moisture from Arabian Sea produces intense avalanche activity in Pir Panjal range.

Avalanche mitigation in India is broadly attempted by two methods - temporary and permanent. Temporary methods include controlled release, avalanche forecasting and awareness. The permanent control of avalanches has not yet matured in India. The rugged terrain, inhospitable weather conditions and staggering prices of putting structure dictates the use of temporary methods for safeguarding affected people from the threat of avalanches. As a technology demonstration projects, a few important regions in Pir Panjal range and some stretches of the outer Himalayan belts, have been explored for structural control of avalanches. The inner Himalayan region, where dry snow conditions predominate, artificial release of avalanches using infantry weapons is employed.

Forecasting is the most preferred method of avalanche mitigation technique followed in India. Efforts are underway to develop different forecasting models suitable for different regions of Himalaya. The practitioners' draw forecast from conventional as well as statistical models to forewarn people about the impending danger. The paper discusses the strategy of avalanche forecasting being used in India; where a blend of conventional and numerical techniques is tried. For operational forecasters, a flow chart for assessing avalanche danger levels in different snow climatic zones has been developed. In spite of the substantial improvement in forecasting tools that are in use these days, the comprehensive assessment of different danger levels in different zones of western Himalaya region have remained elusive. To compensate this void, a massive avalanche awareness programme has been launched to train people in in-situ assessment of instability in snow pack. The pedestrians are also taught to take adequate safety measures while negotiating avalanche terrain. A few rescue teams have been trained and equipped with latest mountaineering equipment and other safety gadgets to launch rescue operation quickly at the time of any untoward eventuality.

Characteristics of landslides occurred within the Nemuro Group in the Akkeshi Bay area, eastern Hokkaido, Japan

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Abstract

The Akkeshi Bay area faces the Pacific Ocean along the eastern coast of Hokkaido, the northernmost island of Japan. A number of landslide-related disasters have occurred within this area, and the Pirikauta, Tomata, Okimanbetsu, and Senpoji Slides are well known throughout Hokkaido.

The bedrock of the landslides consists primarily of shale, sandstone, conglomerate, tuff, and andesite lava of the 3,000-m-thick Upper Cretaceous to Paleogene Nemuro Group, while the moving material consists of relatively fresh rock, weathered rock, debris, and earth derived from basement rocks, as well as surface soil. Rocks in contact with the slip surfaces of the relatively fresh and weathered rockslide material are mainly shale, with lesser tuff. The landslide clays originated from shale consist mainly of interstratified illite/smectite minerals. On the other hand, those from tuff include relatively large amounts of smectite. Interstratified illite/smectite minerals are formed from smectite by diagenesis, which is adding alkali ions and increasing temperature and pressure. This transformation starts by increasing the alkali ion content and smectite changes to interstratified illite/smectite minerals with g=0 in the early stage of the transformation (Shimoda et al., 1986).

On the basis of porosity values of 2.093-14.820 %, and according to the scheme of Aoyagi and Asakawa (1977), shales of the Nemuro Group correspond to the stage of diagenesis. Accordingly, landslides that developed within the Nemuro Group are classified as diagenetic zone landslides. We believe that these landslides were triggered by the swelling of clay minerals such as interstratified illite/smectite minerals and smectite in shale and tuff during periods of heavy rainfall.

Stabilization of Varunavat Landslide in Uttarkashi Town, Uttarakhand Himalaya

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Abstract

Landslides are major natural disasters which disturb the population and damage an eco-balance, especially in seismo-tectonically active regions like Uttarakhand Himalaya. A Huge and massive landslide triggered on Varunavat hill and disastrously affected the life and property of Uttarkashi town lying at the toe of the hill, in Garhwal Himalaya. The moderately steeper slopes of Varunavat hill expose thinly bedded quartzite and foliated meta basic (belonging to Garhwal Group of Proterozoric age) which are weathered, distressed, decomposed, jointed and fractured. Based on the preliminary geological and geotechnical investigations coupled with geophysics and drilling of the slide zone and slope stability analysis using numerical methods, the treatment and stabilization plan was devised and implemented in a phased manner for different parts of the entire slide. Thus an integrated approach was adopted for the long-term stabilization of the area. This paper highlights about the challenging treatment and stabilization works of the landslide which is overlooking the Uttarkashi township and is a constant threat. Considering the huge dimensions of the slide and its critical location, the execution and implementation of treatment plan was a big challenge for the planners, engineers and geologists. Most effective design solutions were adopted for long term slope stabilization to ensure perfect restoration of slope stability and to avert any such incident in future.

Landslide Risk Mitigation Programmes and Initiatives in India

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Abstract

Landslides have affected more than 15% of the India's land are and account for heavy losses of life, economy and environment on a cumulative basis. In order to reduce the landslide risks and support safer sustainable development in the hilly terrains, various landslides risk mitigation programmes and initiatives have been undertaken by different ministries, departments and agencies in the country during the last two decades. These endeavours try to address the multi-faceted problems of data collection, mapping, hazard-vulnerability-risk assessment, monitoring, prediction, warning, emergency response, rehabilitation and redevelopment issues. The paper focuses mainly on the efforts made by the Department of Science and Technology (DST), National Institute of Disaster Management (NIDM), Ministry of Home Affairs (MHA) and National Disaster Management Authority (NDMA). Besides them, there are several other key stakeholders in landslides risk management which play a significant role at different levels. These stakeholders include Geological Survey of India, Border Roads Organization, Department of Geology and Mines in the States, Central Building Research Institute, Central Road Research Institute, Wadia Institute of Himalayan Geology, Indian Institute of Remote Sensing, National Remote Sensing Centre and several other research as well as academic organizations. However, due to space constraints, only few of them are discussed here.

Department of Science & Technology (DST), Government of India initiated a coordinated multi-disciplinary and multi-agency programme on landslides hazards mitigation way back in 1991 for the entire Himalayan region, Western Ghats and Nilgiri Hills. Under this programme, various integrated and interdisciplinary investigation were carried out in the scale of 1:50,000, 1:10,000, and 1:1000-2000. Different methodologies were used to prepare landslide hazard zonation maps. DST published an Atlas on Landslide Hazard Zonation along Satluj River Valley in the year 2006 based on the work done through DST Sponsored Landslide Hazard Zonation Mapping Projects (1992 -1998).The next step in this direction was micro-zonation and site specific studies on landslides. Special attention was given to the study of chronic landslides, their investigation and remediation. Emphasis was also given to generation of proper landslide inventory database and applications of state-of-art technologies to understand and manage landslides. DST has also made some attempts to create infra-structural facilities like establishment of geotechnical laboratory dedicated for landslides investigations and training of manpower for capacity building in this sector.

Ministry of Home Affairs (MHA), the nodal ministry for disaster management in the country, has made Geological Survey of India (GSI) as the Nodal Agency to deal with landslides problems. GSI has established landslide units in those offices working for hilly areas. Landslides have been included in its planned programme of activities as one of the key areas. Geological Survey of India (GSI) has come up with a Landslide hazard map of India in early 90's, demarcating the severity of Landslide hazard in

different parts of the country and also published an Inventory of Landslides in the year 2005. GSI along with NIDM, has developed a format and circulated it to States & Agencies like BRO, CPWD etc. for reporting landslide incidences for input towards updating inventory. MHA has a video-cenference node with GSI as part of emergency landslide support system.

National Institute of Disaster Management (NIDM) has been mandated by the Disaster Management Act 2005 to undertake training, capacity building, dissemination of knowledge / experiences and document disasters as well as good/bad practices for disaster management. Additionally, it assists the Central Government and NDMA in preparation of plans, policies and guidelines related to thematic disasters and sectoral issues besides the multi-hazard, inter-agency and cross-disciplinary areas of disaster management. NIDM is involved in organizing trainings on comprehensive landslides risk management to multi-stakeholders as well as specialized trainings like applications of geo-informatics for landslides risk management. It is working on development of training designs, modules, curriculums and documentaries etc. on specific disasters. The Institute conducts/sponsors research, organizes workshops/conferences, publishes a Journal on Disaster & Development, operates the Centre Sector Scheme to run disaster management centres in different States and Union Territories for capacity building. It has initiated a National Disaster Statistical System (NDSS) to collect and compile database on disasters and is working on two web portals – India Disaster Knowledge Network (IDKN) and India Disaster Resource Network (IDRN) to dissemination information on knowledge and resources related to disaster management. It also supports and promotes other activities related to disaster management in the country.

National Disaster Management Authority (NDMA) has released National Guidelines for Management of Landslides & Avalanches to support the preparation of landslide management plans at different levels. It has also proposed some action points on various issues related to mass movements to reduce the risks in a systematic manner.

Sonapur Landslide and Its Mitigation through RCC Cut and Cover Structure

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Abstract

Sonapur landslide is located at Km 141.800 on National Highway number 44 in Meghalaya State. The slide lies at latitude N 25 °6'30 N and E 92˚21'5". This slide is and active rock-cum-debries slide which got activated in 1988, due to an earthquake in 1987. This slide has extents to a length 200 mtr and approximate height in 370 mtr above the road level. The slide area covers 0.27 Sq Km. The elevation difference between toe of slide and its crown is 400 mtr. The Sonapur landslide is a debries flow type slide . This type of failure is most dangerous and destructive type. A debries flow is rapidly moving slurry water, mud, rock, vegetation and debries and large boulders. Geological investigation carried out and as per sample collected rocks consist of medium grained sand stone with inter bedded slit stone and gray splintery shale on weathering shale because platy and splintery sand stone are forming scraps faces and dip slope bench. For last 20 years, the entire population of Barrak Valley, Tripura, Mizoram and part of Meghalaya &Manipur suffered, few people lost their lives . The entire used to remain cut off from the rest of country for a period varying upto few days to two months since 1988. The concept of Cut and Cover structure as permanent solution to the problem was suggested on 28 Sep 2007 in a meeting presided by Secretary, MOSRT&H held at Guwahati. Approval of the work received in Dec 2007 for Rs 11.77 Crores. The work commenced in January 2008 and the Tunnel structure has been completed in a record period of nine months. This Tunnel is 123 mtrs long RCC Cut and Cover structure capable for double lane traffic. The Sonapur Cut and Cover structure is a unique structure and has been constructed for the first time and its first of its kind in our country across an active rock-cum debries slide to provide safe passage to the traffic. This Tunnel will mitigate 20 years old perpetual of Sonapur land slide for more than 10 million population of Barrak Valley of Assam, Tripura, Mizoram and part of Meghalaya and Manipur. This concept can be further extended to other trouble spots to provide safe passage, to traffic and pedestrians

Preliminary Analysis of Spatial and Temporal Variation of Landslide Hazard in India (Period between April 2007 and March 2009)

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Abstract

Landslides constitute one of the most damaging disasters forIndia and affects its 15% area, spread over 22 States and one Union Territory. Almost all landslides are located either in the Himalayan and the Arakan-Yoma belt of the North-Eastern parts of the country or the relatively stable domains of the Meghalaya Plateau, the Western and Eastern Ghats and the Nilgiri Hills.

It is an endeavour to try to envisage a mechanism towards critical understanding of the behaviour of landslides and evolution of a relationship between landslide incidences and rainfall. The development of data bases depicting the spatial and temporal distribution of hazardous events has been relied as an essential input for assessing the status of hazard and managing the risk arising from it. It is known that the landslides occurrences, both spatial and temporal, vary significantly. The former depends mainly on geological and geomorphological conditions whereas the latter is correlatable with monsoon phenomenon.

The entire exercise/analysis is based on data, pertaining to two years, viz., 2007-08 (April through March) and 2008-09, gathered from media reports, central/state government bodies/departments, NGOs, private agencies and individuals. The annual period incorporates advancing SW monsoon followed by its retreat. Information on 445 landslide incidences has been assembled for 2007-08 and 59 for 2008-09. It has been observed that almost all landslides were preceded either by rainfall for long period or short duration high intensity rainfall. Unfortunately, there were 226 human fatalities in 2007-08 and 82 in 2008-09.

The data collected from the specified sources has several gaps due to inherent limitations in data collection network and to some extent in data transmission. Many of the landslide spots were visited by geological teams from various regions/state offices of Geological Survey of India for on the spot assessment and conducting geological studies and tendering alternate/remedial measures.

The paper discusses the intensity of landslide hazard in different parts of the country, the density of casualties resulting due to landslides and also attempts the correlation of landslide density with monsoonal activity. The distribution and trends helps in identifying gap areas of information inflow and it can also be inferred that the impact of the hazard is far more severe than indicated by the available data.

Hazards Mitigation through Application of Bioengineering Measures in Landslide Areas: A Case Study of Varunavat Landslide, Uttarkashi (Uttarakhand)

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Abstract

Landslides are common feature in the mountain ecosystem and are accelerated either due to natural factors such as lithology, structure, slopes, hydrological regime or anthropogenic factors viz., deforestation, road construction, mining, hydroelectric project, urbanization etc. Besides disturbing natural fabric of ecosystem of the area, these landslides are also known for huge damage to the public and their property. Once these landslides have occurred, massive amount of debris containing soil, small and big boulders are generated and deposited. If appropriate measures for protection of these loose materials are not attempted, a continuous fear of damage to the ecosystem as well as to public property remains there. Vegetation which has capability to protect loose materials through spreading their root network and crown foliage can be used to arrest further loss to the ecosystem and society in landslide damaged areas.

Varunavat landslide in district Uttarkashi which occurred in September 2003 is a recent example to the damage of ecosystem and public property. To check further damage due to erosion of loose materials and resulting loss to the property in Varunavat landslide area, application of bioengineering measures which included the use of number of suitable plant species has been practiced.

The present paper discusses the importance of bioengineering measures and species used in arresting damage in Varunavat landslide.

Forecasting Erosion Induced Landslide

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Abstarct

Soil erosion is globally recognised as a serious threat to the human's well being. The basic definition of the word "Soil Erosion" commonly means the destruction of soil by the dual action of water and wind. It is essentially a smoothing process with soil particles being carried, rolled or washed down by the gravitational force. Erosion induced landslide is fundamentally a continuous process caused by two prominent means of disturbance either geologically or accelerated that affects the geotechnical strata and the surface of the earth. The severity or impact on the soil strata depends significantly on the rainfall intensity, energy and magnitude of the rainfall erosiveness which scour away, loosen and breakdown the soil particles and carry then away besides the degree of soil erodibility itself. A combination of these two main factors namely rainfall erosivity and soil erodibility can be used as a predictive tool in forecasting erosion induced landslide. By knowing the level of rainfall erosivity and soil erodibility impact of an area, the potential risk of erosion induced landslide can be made known.

A2/10

Landslide Hazard Mitigation – Aspects related to Geotechnical Investigations

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Abstract

Landslides have been one of the major natural hazards that have been commonly experienced in hilly terrains all over the world. In India, the incidence of landslides in Himalayas and other hill ranges is an annual and recurring phenomenon. There is a variation in degree of occurrence in various hill ranges. The landslide incidences have reportedly increased ever since the road and other infrastructural developments have taken greater pace in hill areas.

The probability of slope instability is dependent on complex interactions among a large number of factors encompassing geotechnical, geological, hydrological, climatic and several other conditions besides the influence of developmental activities. The slope failures observed along the road sections in different hill ranges vary from small erosion cut to creep, subsidence, deep seated failures, debris flows, debris slides, rock slide, rock fall, slumping failure etc. The landslide correction technique or the approach to deal with slope instability problem should, therefore, take into account the various factors whose interactions cause the slope instability. At the same time, the landslide investigations should be planned in a rational fashion since these investigations takes enormous amount of time, expenses and some time involve lot of risks.

The present paper is intended to present a couple of case studies involving different aspects of geotechnical investigations and intend to highlight the limitations of these investigations.

Instability of the Slopes in Uttarakhand State-serious threat to the Natural Ecosystems and Human Settlements

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Abstract

Uttarakhand state is one of the fast developing states of India as it possesses a lot of resources and financial assistance from the Centre. But in the course of this haphazard development, the state could not check the encroachments to the hilly regions by various developmental activities. This aggravated the problem of slope failures which were already unstable due to their geoclimatic and geodynamic conditions. The state is much prone to the natural disasters like earthquakes, mass movements, forest fire, lightning, flash floods etc. but most frequently encountered are slope instability problems. The major reasons for this instability are the loss of forest cover, unfavorable human activities, water seepage into the soil due to heavy rains, drainage systems, reservoirs, etc. The unstable slopes are triggered by heavy rains, earthquakes, floods and human actions such as mining, deforestation, blasting, slope modification, drainage blockade etc. resulting into the landslides. The state faces loss of many lives and property every year. In most of the hilly regions, people are investing a lot of money in various projects like constructing school, colleges, hotels, flats and villas, small industries, etc. For their purpose, they first clear the hill slope and then construct the desired asset. This highly disturbs the stability of the slope badly resulting in future threats to the area in the form of slope failures. The instability of the slopes is a serious threat to the natural ecosystems as many of the endangered and threatened species of flora and fauna have the danger to become extinct. Also human settlements are vanished completely when these unstable slopes fail to retain the top cover. The time has come that the activities disturbing the stability of slopes should immediately be checked and the massive conservation and environmental development programmes should be started to minimize the slope instability.

A2/12

Geological Investigations of Hazardous Landslides Sites on Rishikesh-Neelkanth Region of Pauri Garhwal District, Uttarakhand

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Abstract

Natural hazards in the Himalayan terrain are not uncommon due to its tectonic setting and immature topography. Among various hazards landslides, earthquakes, snow avalanches and cloudbursts frequently damage the landscape and taking heavy tolls in terms of loss of life and property. In terms of frequency landslides occur much more than the others.

The state of Uttarakhand has several districts in which natural hazards particularly landslides are major problem. Geologically being fragile with relatively young lithology together with continuously increasing population as well as tourists/pilgrim load is only making this problem more challenging. Rishikesh is the main entrance of Uttarakhand state from which nearly all pilgrims enter and is therefore of greater importance. In this region most vulnerable sections are pilgrim routes (both foot track and motorable) located in abruptly rising mountainous terrain of Lesser Himalaya. Over a million pilgrims use these routes two times every year for paying their homage to Lord Shiva besides routine use by the local inhabitants, particularly in the peak rainy months of July and August. Incidentally in this duration the probability of operation of mass movement processes are maximum hence a good number of pilgrims are always at risk. Besides frequent incidences minor and major slope failures and subsidence causing substantial devastations to properties and civic infrastructures and occasional loss of lives.

Geologically the study area falls in the northeastern most part of the outer Himalayan Quaternary Doon valley near Virbhadra barrage and the northwestern part of Garhwal Synform of the Lesser Himalaya. The area is moderate to steeply sloping with well developed drainage network.

Landslides are reported from 33 places on the metalled road out of which 11 are categorized as major landslides. All major landslides composed mainly of shale, phyllites and limestone. The slides are either boulders or rock slides and are planar to curviplanar in nature.

On foot track, four landslide zones-Dhandlapani-Maunibaba Ashram, Upper Dhandlapani, Pundrasu I and Pundrasu II have been observed. The largest landslide among these is Dhandlapani-Maunibaba Ashram landslide. Approximately entire foot track passes from this landslide, hence get repeatedly damaged. This landslide appears to be of tectonic origin as thoroughly crushed phyllites of Subathu Formation are exposed in this landslide zone. The Upper Dhandlapani landslide facing the Tambakhani watershed is nearly 300 m long and upto 60 m wide. The Pundrasu I and Pundrasu II landslides are basically loosely poised landslide masses of few hundred to less than ten meters long boulders of fossiliferous Neelkanth calcareous sandstone forming the subvertical to vertical scarp.

A2/13

Investigation And Remediation To Restore The Slopes Of National Highway- 87 In Amparav Area, Uttarakhand, India

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Abstract

Incidences of landslide hazards are quite common in the Indian Himalaya. These landslides are mainly responsible for creating frequent disturbance to the traffic on hill roads and consequent increase of Socio-economic problems. Landslides results in loss of life, property and disruption to traffic, which requires efforts for relief measures, restoration works and also necessitates of alternate routes for traffic. The incidence of landslides and its destructive efforts can be controlled to a great extent by preventive and protective works at the time of initiation of the landslide. The adverse natural conditions that trigger off slides are so complex that all the causative factors are difficult to quantify and as such as total success in correction or prevention of slides cannot be relied upon. Amparav is one of the major landslides, situated SSE to the lake city Nainital above the Kathgodam - Nanital road (NH-87) in Kumaun Division of Uttaranchal State. Amparav landslides were responsible for the loss of lives and property, besides the closer of NH-87 for a considerable duration. This road is important and leads to the Nainital and other border areas. The whole area is still active and there are many subsidence and failures are reported close to the NH-87. An attempt has been made to study the failures close to National Highway to restore the slope adjacent to the NH-87. The study broadly covers the geological & geotechnical investigations, laboratory testing and a detailed analysis of the data obtained. The paper highlights about the investigations and remedial measures, which have been carried out to restore the slopes.

Landslide Scenario in Kashmir Himalayas: An Overview

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Abstract

Among the various hazard prone Himalayan states of India, the state of Jammu and Kashmir is all the more vulnerable to almost all the hazards. The historical records reveal that the Kashmir Himalayas has suffered heavy casualities and loss of properties due to landslides, earthquakes, floods, avalanches and so on. The results of the first investigation on historical landslides that occurred in Kashmir Basin since Pre-Historic times are presented. Our study highlights spatio-temporal distribution of landslide events, in J&K State. The methodology included research of historical sources at national institutions, public libraries, international journals, the Internet, and the collection of original texts from newspapers and their transcription in analog format. Analysis and interpretation of the data was performed, followed up by the digitalization of landslide spatial locations using the software Arc GIS and the integration of the landslide attributes in a structured query language (SQL) server database. The study shows that these events occurred mostly in combination with other natural phenomena vis-à-vis earthquakes, floods, snowfall, rainfall besides, anthropogenic activities that led to increased sensitivity of the land surface and an increase in the frequency of landslides. The collected data is part of inventory of hazard events, including information about damage and human losses caused by them. The present study provides the basis for a more comprehensive future landslide hazard assessment in Kashmir Basin.

A2/15

Some observations on geomorphic features developed in landslide prone areas of Chamoli –Badrinath ji road section in Garhwal Himalaya .

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Abstract

Central Crystalline zone of Chamoli Garhwal is marked by number of landslides along Alaknanda river valley and its tributaries. This section is marked by both old as well as new landslides. Most of the new landslide activity is reported to take place along faults during Chamoli earth quakes. The landslide activity is controlled by natural as well as anthropogenic activity and hydrological action. Endogenic forces slowly operative in this region is bringing out changes in morphology. The streams show anomalous drainage behavior wherever they cross the lineament and the impact of structurally weakened rocks is seen in term of landslide occurrence. Main Central Crystalline zone of Alaknanda valley is characterized by NW-SE and NE-SW oriented faults related with imbrications of duplex thrust system. These faults and MCT is active and is marked at places by seepages and water falls up to 60 meters. Chamoli-Badrinath section is characterized at various places by the fluvial sedimentation pattern in term of clast supported and matrix supported material with silt and sand layer depicting nature of sedimentary sequence of episodic uplift by reactivation of the cross faults. The present study is based on IRS-1b-L2B2 1:50000 scale data supplemented by ground survey data. The tectonic rejuvenation of MCT and cross faults has resulted in the development of tectonic landforms such as terraces, fault scarps, gorges, triangular facets. These faults has movements, therefore, straightening as well as channel shift from N-S to almost W direction is unique phenomenon in between Chamoli-Badrinathji section. The V shaped straight river course at Helong Pipalkoti, north of Kheroganga-Alaknanda junction, Thaiya bridge to Dholiganga junction, north ward section of Birehi-Alaknanda junction shows active channel of river Alaknanda. The uplift of fluvial terrace at Pipalkoti and Kalpeshwar Mahadev, scouring of terrace at Kheroganga and Pipalkoti and dense rupturing of terraces at Barsu and Dungri villages is suggestive that the area is tectonically active. Stretching of straightening river channels, terraces depositional environment and its dating supported by morphometric data suggest that neotectonic activity is controlling the landslide occurrence in this domain of MCT shear zone.

Stability Analysis of Surbhee Resort Landslide in Garhwal Himalayas, India

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Abstract

Landslides are one of the frequently occurring natural hazards in seismically active North-West part of Indian Himalayas. In this study, an endeavour has been made to model Surbhee Landslide (longitudes 78°02' and 78°04'E and latitudes 30°28' and 30°31'N) in the Dehradun and Tehri districts of Uttaranchal located in Mussoorie. This landslide is active on the road that is joining main road to the down town. This landslide was triggered because of rainfall in July-August 1998. The landslide is still active and there is a need to do some scientific investigations to mitigate future damage. Therefore, a 2-D model has been carried out with the Distinct Element Method (UDEC) to understand the mechanism of slide that will decipher the weak zones (fractures) in the sliding area.

Study has been carried out in two stages. In first stage, total slide has been modelled in 2-D. From this, it can be concluded that the zone of detachment is the most vulnerable part of the slide. With reduced friction angle due to ingress of water, the top layer of the zone of detachment starts moving. This top layer in the field is the weathered material. Slope is stable otherwise under static and dynamic loading cases. In second stage, only the zone of detachment has been modelled in 2-D. Study under static and dynamic environment indicates that most of the total displacement observed in the model of the slide is due to the zone of detachment. The numerical results indicate the effect of degradation of discontinuities and dynamic environment based on the amplification of the input loading results in the instability of the top layer of the slide. Both sliding and rotation contributes to the failure of the blocks.

The above studies have provided an insight into the deformation mechanism of the blocks formed by rock discontinuities. The discontinuum modelling in the present study has modelled the field situation in accurate manner to have a better understanding of the stability of the slide. Understanding the behaviour of the landslide will be helpful for planning and implementing landslide mitigation measures.

A2/17

Landslides Hazards Assessment: A Case study for the Hydropower Project in Garhwal Himalaya, India

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Abstract

Hydroelectric facilities are vulnerable to several types of natural hazards. This vulnerability is a consequence of the factors necessary to generate hydroelectric power. Landslides are one of the most pervasive natural hazards. This hazard affects hydroelectric facilities in several ways. Landslide movement can remove support to the foundations of power stations, switchyards, dams, and other structures. It can also affect the function of these facilities by impact or burial from locations upslope. Landslides deliver large amounts of sediment to streams and rivers. This sediment can exceed the ability of intakes to prevent its entry into pipeline and cause damage to turbines. Over time, sediment from landslides can affect the efficiency of diversions and reduce the storage capacity of reservoirs.
Preparation of Landslides Hazards assessment map is important for engineering work. However, due to complex nature of landslides, producing a reliable landslides hazards assessment map is not easy. In present study Landslide Hazards assessment has been carried out in and around Vishnugad - Pipalkoti Hydropower (444 MW) project, proposed on Alaknanda river using advanced remote sensing and GIS techniques. The study area lies in the southern mountain front of the Main Central Thrust (MCT). The project area forming a part of Alaknanda valley exposes rocks belonging to Garhwal Group and Central Himalayan Crystalline, composed mainly of calc arenaceous rocks with basic intrusive and migmatite bodies.

The study area presents extremely rugged topography with steep valleys, the rivulets and tributaries cut across and negotiate the mountains with rapids and steep gradients. The river Alaknanda has steep slopes and perennial discharge. In general the northern slopes are gentler as compared to southern slopes due to influence of dip slopes. The valleys are V shaped, steep with narrow gorges. Spatial data sets such as lithology, rock weathering, geomorphology, lineaments, drainage, land use, anthropogenic factor, soil type and depth, slope gradient, and slope aspect were integrated using expert knowledge based method. The final map was reclassified in to five classes such as highly to lowly susceptible classes based on cumulative cutoff. The prediction performance of the Landslides hazards assessment map is check by the considering actual landslides in the study area by the field investigation. It is believed that the approaches employed in this study mainly prevent subjective sources from the parameter selection and provides a support to improve the landslides hazards mapping studies.

A2/18

Spatial Multi Criteria Analysis for Landslide Susceptibility Zonation

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Abstract

Landslides cause widespread damage to human life and property in the Himalayas every year. Due to huge pressure of urbanization and developmental activities in the mountainous region, landslide studies have drawn greater attention in the past few decades. As a result, several landslide susceptibility zonation (LSZ) methodologies have been evolved to demarcate mountainous terrain based on its susceptibility to landslides. For accurate LSZ mapping, detailed landslide inventory with nature of mass movement and history of activation or reactivation are required, which in most cases in Indian context are not either collected or maintained systematically. And hence, the opinions of the scientists are divided in favour of qualitative and quantitative analyses. To resolve the conflict, a combination of qualitative and quantitative method called Spatial Multi-Criteria Analysis (S-MCA) has been tested in the Chamoli region of Uttarakhand. In this method the thematic layers (viz. slope, aspect, relative relief, tectonic structures, lithology, landcover and drainage density) are generated using remote sensing and GIS and are weighted using a pair-wise comparison of various factors based on experts' opinion. The final output map has been compared with maps generated using other standard LSZ methodologies.

A Reconnaissance Study of Some Landslides in Goa, India

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Abstract

The paper presents observations of some landslides in Goa, India and includes site specific information on location, geology, causes and impacts of landslides, field characteristics, various mitigation measures undertaken by concerned departments and the efficacy of remedial measures. Landslides in Goa mainly occur during the rainy season when rocks or sediments, particularly laterites fail due to ingress of water. Appropriate drainage measures, reinforcement of slope mass, construction of retaining walls and restoration of the slopes altered by human actions have been commonly practiced to prevent and mitigate the impacts of slope failures. Additionally, important buildings like Governor's Palace, which have been affected by landslides, are being periodically monitored using displacement measuring instruments. Some of the critical facilities like ID Hospital and basic amenities such as drinking water supply etc. have also been found to be at risk due to landslide activity. Besides Important buildings, critical facilities and basic amenities, heritage sites and buildings in Malla area, Panjim hills too are adversely affected by slope stability problems.

The survey indicates that there is an urgent need to study these landslides in a holistic manner so as to avoid future landslide risks to the people, properties, infrastructures and other developmental activities in the region. The state is now working on the preparation of a landslide risk management plan to cater to these needs and build its capacity against the consequences of landslide disasters.

Identification of Critical Locations in a fissured Rock Slope

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Abstract

There are various reasons causing landslides. Presence of fissures in a rock mass is one of them and makes landslide more vulnerable. Rock masses have numerous fissures of varying length and thickness. The fissures may be located anywhere in the rock mass depending upon geological weathering and disturbances. It is therefore important to study the in-situ stress variation due to the presence of these fissures, which is going to help in suitable site selection for the future structures to come on the rock slope.

In this paper a study has been carried out on a steep rock slope using the finite element method. The finite element model incorporates the modeling of the fissures with a parametric study of its location and length of the discontinuity etc. The results of stress concentration pattern due to fissures within the rock mass are presented. The identification of the critical location of the fissures becomes very important in this situation which is duly addressed.

Instrumental Monitoring of Mansa Devi (Haridwar) Landslide Site and Interpretation of Data

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Abstract

Landslide has the second rank in the amount of damages due to Natural Hazards. This phenomenon effects in different areas like roads, near by villages, power line & so on and leaves behind a destructive effects. Usually the main problem with landslides are its area, velocity and acceleration, since, their measurement plays an important role in estimation of damages and needed precautions. It is found that landslides are initiated by small movement of slopes and with a period of time , which combined with natural or man made factors lead to a of larger magnitude and it would have not been true if proper monitoring could have carried out since beginning. The Science of landslide is rather difficult. It needs a lot of observations of different kind. Several monitoring techniques have been devised for the pre detection of the landslide to check the devastating effects and damages caused by them. Most important among them is Instrumental Monitoring of landslide, which enables the evaluation of the amount of displacement in different areas & then the knowledge of landslide mechanism. Here in this paper authors have highlighted various Instrumentation schemes for landslide monitoring & early warning; And also have explained an instrumentation scheme adopted for mansa devi (Haridwar) landslide site and interpretation of the recorded data of a small catchment/area. It is observed that, this landslide which occurred almost a decade ago and completely damaged the 300 meter stretch of the Haridwar by pass road and posed a serious threat to the residential, commercial establishment, railway track of Haridwar Township located at the basement is still an active slide.

A2/22

Importance of Mesoscale Landslide Hazard Zonation in Planning and Development of Lunglei Town, Mizoram

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Abstract

The state of Mizoram is having strategic and economic importance; even then the state remains largely underdeveloped because of its inaccessibility. Now the state is undergoing progressive development through construction of roads, hydroelectric projects, urban agglomerations etc. This human interference with the nature is one of the most important causal factors for landslides in the region. Every year this phenomenon particularly during monsoon months accounts for considerable loss of life and damage to human settlements, civil structures, communication routes and agriculture & forest lands,. Lunglei is the second largest city in the state and is growing day by day. The mountainous terrain of the area is characterized by steep slopes, high relative relief, weathered, fractured and folded rocks with adverse hydrogeological conditions. The situation aggravates further due to anthropological activities such as deforestation, jhum (shifting) cultivation and unplanned developmental activities on fragile hill slopes. Lunglei town, the headquarter of Lunglei district, Mizoram, witnessed devastating landslides in 1995 at different places.

For the evaluation of the slope stability condition of the Pachang – Lunglei - Zobawk area, Lunglei district, Mizoram, first macrozonation of about 150 sq. km. area has been carried out. On the basis of the results of the macrozonation of the area, nearly 28 sq. km. area in and around Lunglei town, which falls mostly in higher side of hazard zone has been taken up for the second generation mesoscale landslide hazard zonation on 1:10,000 scale, to identify and delineate unstable hazard prone areas. The mesoscale landslide hazard zonation map of the area has been prepared based on the modified BIS (2004) guidelines. Twelve geo-environmental parameters viz. slope morphometry, relative relief, landuse, landcover, lithology, intact strength of slope material, structure, hydrogeological conditions, rainfall, stability status of slope, seismicity and slope erosion have been taken into account. On the basis of slope characteristics a total of 149 facets have been delineated in the area. Different thematic maps have been prepared and the Total Estimated Hazard (TEHD) of each facet has been calculated based on TEHD values. The mapped area has been divided into four hazard zones, viz. Low Hazard Zone (LHZ), Moderate Hazard Zone (MHZ), High Hazard Zone (HHZ) and Very High Hazard Zone (VHHZ). Out of total 149 facets, 63 facets (42.28 %) fall in low hazard zone, 48 facets (32.21%) fall in moderate hazard zone, 34 facets (22.82%) fall in high hazard zone and only 4 facets (2.69 %) fall in very high hazard zone. This map would help planners and engineers in the long run to identify suitable areas for implementing developmental schemes, as well as, for adopting appropriate remedial measures in hazard-prone areas to minimize the loss/damage.

A2/23

Landslide Hazard Zonation Atlas of Northeast India

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Abstract

The present study highlights the preparation of Landslide Hazard Zonation ATLAS of the North-eastern India using GIS techniques. The ATLAS is an outcome of the LISMAP, a collaborative project taken up by Defence Terrain Research Laboratory (DTRL), New Delhi and the Department of Earth Sciences, Manipur University for Border Road Organisation (BRO). In this study ERDAS Imagine 8.4, MapInfo Professional 5.5, ARCGIS 8.1 have been used for generating various GIS thematic inputs whereas the Landslide information system (LIS) software, developed by the DTRL, is tested extensively for the generation of Landslide hazard zones and landslide hazard management in northeastern region. The LIS software is successfully tested by field validation of many active landslides falling in the high to vary high landslide hazard zones.

A2/24

Rock Fall in Panthal Area at Km 168.50 on Jammu-Srinagar (NH-1A)- A Case Study and Remedial Measures

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Abstract

The paper attempts to set forth the essential soil mechanics aspects of some of the landslides types encountered, in the Himalayan regions by Border Roads Organisation in general and on the Panthal landslide on NH-1A i.e Jammu-Srinagar road in particular, the method of correction appropriate to them, the importance of drainage in slope stabilization. Salient features of common landslide type is delineated with a view to providing inputs for discussion on the seminar to arrive at a more permanent solution. The subject is so wide-ranging that only certain selected aspects can possibly be taken up for consideration one paper

A2/25

Characteristics of Avalanche Accidents in Western Himalayan Region, India

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Abstract

Avalanches have rocked Himalayan belt since time immemorial. However their hazard potential was felt only in late nineteenth century. A series of accidents in early fifties and sixties of the twentieth century urged for setting up of a Defence establishment to take care of the mitigation of the hazard. Avalanches killed only a small proportion of the original inhabitants of Himalayan region. The inhabitants, it is assumed, might have suffered heavy casualties in the beginning of their settlement in the avalanche prone regions of Himalaya. With trial and error they located the safer places and their daily activity remained mostly confined to the four boundaries of their premises. The hazard increased with the movement of troops in inner belts of Himalayan region. Since then avalanches have been taking their toll, both of Army and the civilians who are operating in avalanche affected areas during winter month. Summarizing the evolution and progress of the avalanche accidents in Western Himalayan region, the authors opine that with the increase in the population in Himalaya and winter sports, the threat is likely to assume greater proportion in near future. Only through quality education programme, avalanche accidents can be reduced.

A2 /26

Rainfall influence Landslide and Risk Mitigation in Sikkim Himalaya

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Abstract

Landslides happen as natural phenomena in hilly terrains and also owing to disturbances reasons with construction activities, e.g., housing and transportation. Natural slopes which contain traditional a stability by the geographical and geotechnical features of the area obtain troubled through human procedures like mining, deforestation and road structures which perforce are required to fulfill the development desires of the region. Failures of slopes generally happen during major earthquakes and apart from liquefaction, frequently constitute the most observable and damaging landslides. Gradually increasing and devastating consequences of Landslides turned up as one of the most important Hydro-Geological Hazards at Sikkim Himalaya.

The rock consists of Phyllites and schists and therefore the slopes are highly susceptible to weathering and prone to erosion. These, combined with the intense rain, cause extensive soil erosion and heavy loss of soil nutrients through leaching. As a result an intense and frequent landslide occurs in and around Sikkim causing a hazardous situation. The recent most catastrophic rainfall, unleashing landslides and another arrogant face of disaster and followed by emergency operations at Sikkim created a new domain of research in terms of disaster management. Landslides may cause disastrous disasters in urban areas and hilly areas. Accordingly area and temporal prediction of landslides can effectively decrease landslide disasters due to appropriate land-use planning and early warning. Each year, landslides around the world create huge economic loss and disruption, and often result in loss of life. Landslides can occur almost anywhere, from man-made slopes to natural and pristine ground. Landslides have resulted in some of casualties and huge economic loss in hilly area in Sikkim.

Landslide Disaster and its Mitigation- A Case of Gangtok, Sikkim

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Abstract

A landslide is a rapid sliding of large mass of bed rock. Infact, whenever the mountain slopes are steep, there is possibility of large disastrous landslides. It is a type of natural phenomena occurred mainly on the steep slopes of hills on mountains due to the gravity of saturated rock debris. The rapid movement of a mass of rock, debris or earth down a slope separated from stationery part of highlands produced disastrous effect on the natural environmental and man-made structures, weakens infrastructural facilities, makes people homeless and disrupts productive bases. Though landslides are local phenomena, the loss of life and properly due to its affect is particularly seen more in recent years. Landslide, mass movements and slope instability are common and serious geo-nvironmental problems and process in the Himalayas. Gangtok, the tiny capital of Sikkim state has been hit by different kinds of landslides in the recent past. Landslides of varied types, degree and intensity have always been damaging seriously the life and property of the area, particularly in the rainy season. Study reveals that recent unplanned and haphazard developmental activities in and around Gangtok have been aggravating the landslides incidence to a disastrous and great extent.

The micro-zonation approach or the hazard mapping is one of the most modern options towards the management and mitigation of landslides hazards of highland landscape. However, the disastrous affect of landslide study of Gangtok has been carried out using data for various geoenvironmental parameters viz. lithology, slope, drainage, rainfall and forest. Landslide Susceptibility Index (LSI) also assigned for the purpose.

Base on these parameters and their relationships, the hazard zonation map has been prepared to show the different kinds of hazards zones of the region. Study confirm that 54.27 % area of Gangtok falls under high hazard zone, and is always at the edge of high risk. It is important to note that Gangtok is lies on the high seismic belt of India , and the MBT (Main Boundary Faulty) has also passed near the region. At the end of the discussion researchers tries to give some appropriate applied time-bound solution of the problem.

A2/28

Use of Real-time Instrumented Monitoring System for Landslide Risk Management

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Abstract

The paper describes innovative use of a real-time instrumented monitoring system for the management and mitigation of risks associated with a retrogressing riverbank landslide. The monitoring system comprised an array of in- place inclinometers, piezometers and slope indicators, which were monitored in real-time using a data logger connected to a cellular modem. The instrumented data was uploaded hourly on to a web server with alarms set for significant changes in slope movement and pore-water pressures. The system proved highly successful in alerting the motorists using the highway located on the crest of the landslide when the landslide became fully active, resulting in slumps of the order of 1 m. the use of this monitoring system mitigated the risks associated with this landslide and prevented loss of lives. The paper also proposes the use of similar systems in landslide-prone areas of India.

Stability Assessment of Rock Slope in Luhri area, Himachal Pradesh

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Abstract

Due to the rapidly growing Hydro-electric power project, population of the Luhri area and increased traffic congestion, it becomes necessary to widen the National Highway (NH-22), which is connected by Hindustan Tibet Road. Landslide is a very common geo-engineering phenomenon in this area due to road widening activity and frequently causes instability problems in both the large and small scale. The cut slope through various rock types like Quatz Mica Schist, Quartzite, Slate and Limestone are highly jointed, folded in nature and causes local degradation of the slope. The state highway at Sainj and Luhri area suffered intensely and several places seriously damaged due to landslides caused by flash flood during June 2005.On August 14, 2007 a huge landslide due to cloudburst which has been occurred in Dharla village near Rampur where 62 people have been reported died.

The paper deals with stability analysis of rock slope in Luhri area, Himachal Pradesh. The road cut slope is mainly characterized by different rock types with varying slope geometry and geo-mechanical properties. Extensive field study and laboratory experiments were conducted to calculate the various physico-mechanical properties of rock mass which will be later on used as input parameters for the safe and stable design of civil construction with proper attention. The failure analysis was carried out using GALENA software in both the dry and wet condition. The present study reveals that the slope is critically stable but any local or global disturbance may further reduce the FOS and causes the failure. Suitable remedial measures have been recommended for strengthening the existing slope.

A2/30

Degradation of soil and its impact on landslide in Garhwal Himalaya, India

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Abstract

Soil is one of the most important natural resource. As a natural resource, soil is of immense value to human beings. Soil is the base to provide support to the most life on earth. Soil is the product of weathered rock, intermixed with living organisms and decomposed materials.

Soil is the prime factor in the process of mass movement like solifluction, creep, talus etc. Soil is integrally and intimately connected with the rocks beneath, the vegetation growing above, and the water percolating through it. Soil moisture plays an important role in determining the stability of a soil on a hill slope.

In the Mandakini valley and part of Alaknanda watersheds of Chamoli district several examples supporting this hypothesis have been registered. The soil studies were carried out in various landslides sites in the study area. The soil study has also indicated that though a combination of various factors led to the slope instability in the Mandakini and part of Alaknanda watersheds of the study area, the prevailing soil condition has significantly activated a series of landslides of smaller magnitudes. The fine textured deep soils on the side slopes under unstabilised terrace cultivation when get saturated with water, slowly slides down under the force of gravity. The content of coarse fragments in the subsurface further lubricates the saturated profile and loosens the mass of soil, which tumbles down the slope.

The management of soil is most important in the mountain region of Uttarakhand. In the area, the management of soil in an efficient manner and on a permanent basis is not only the need of the agricultural community of the region alone but it is equally necessary to stabilize the slopes in order to maintain the hydrological balance and to avert any possible crisis of water scarcity and problems associated with land degradation, slope failures, silt accumulation in streams and the havoc of flash flood in the future.

A2/31

The relationship between ancient landslides and hydrothermal alteration zones in southern part of Okushunbetsu landslide area in Teshikaga district, eastern Hokkaido, Japan

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Abstract

The topographic expression of two ancient landslides, the Ohekisawa and Shikerebenbetsugawa Slides, has been identified in the southern part of the Okushunbetsu landslide area. These landslides are hydrothermal alteration zone landslides and the bedrock has been intensely affected by Pliocene hydrothermal alteration and mineralization.

The Ohekisawa Slide formed upon a dip slope of coarse tuff and tuffaceous medium sandstone from the Upper Miocene Shikerepe Formation. These rocks are hydrothermally altered, and have a mineral assemblage indicating smectite and mordenite zones.

The Shikerebenbetsugawa Slide developed upon a dip slope of fine tuff, mudstone and lapilli tuff from the Upper Miocene Hanakushibe Formation. These rocks are also hydrothermally altered, and include smectite and laumontite zones.

The hydrothermal alteration products, smectite, mordenite and laumontite are closely associated with the ancient landslides, suggesting that landslide potential within a hydrothermal area can be assessed on the basis of hydrothermal alteration type.

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A2/32

Evaluation of Morphological and Geological parameters in landslide susceptibility mapping by Using Fuzzy Logic

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Abstract

Assessment of Natural slope instability is one of the most important phenomena in geology and geomorphology, which plays a very important role in the changes on land surface and affects environment. In this research, landslides located in a part of Haraz watershed were determined by using aerial photos and field studies, then landslide susceptibility zoning by using morphological (slope, aspect and elevation) and geological (lithology and distance of fault) were used to evaluate landslide susceptibility. Each one of effective parameter was taken into consideration and saved in ILWIS software environment and for analyses using fuzzy set theory. Fuzzy analyses were made by using MATLAB 7.1 software. Before that, a membership function for each effective parameter on landslide was defined. Then, degree of susceptibility for each pixel in study area was calculated, and landslide susceptibility map of the region was produced. The results showed satisfactory agreement between the landslide susceptibility map and the existing data on landslide locations.

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Analysis of Chakhabama subsidence along NH 150, Nagaland, NE India

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Abstract

This subsidence zone, lying at 94°11'43" E longitude and 25°39'09" N latitude, is about 60 m in length with a vertical subsidence of 2 m. The area has a thick cover of long grass with some shrubs. A power cable post in the area has tilted due to soil creep. Curved tree trunks are noted in the subsidence zone. The regionally folded Disang Group of rock in the subsidence zone includes crumpled and weathered shale. A stream channel within the area has a stepped configuration with shallow waterfalls of up to 50 cms height. Base level and toe erosion are vigorous processes in this channel. Subsidence is due to shearing in this zone. Two parallel faults traverse the area. Three to four sets of joints cut across the rocks.

Rock samples are collected for determination of Rock Mass Rating. About 40 rock samples are collected from the site to determine the strength of the rocks using a Point Load Index Tester. Joint trends obtained, are plotted in GEOrient software to construct pole and contour diagrams to determine the dominant joint sets. These are used to generate stereographic projections for the joints. Integrating all data, the Slope Mass Rating is evaluated. The test indicates that the rocks are very weak and highly unstable. Factor of Safety is calculated using the Markland Test. This section of the highway is vulnerable to major landsliding in the future.

A2/34

Probabilistic Classification-based slope stability evaluation of Lukuvir slide, Darjeeling Himalaya, India

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Abstract

Detailed geological mapping (1:1000) and rock mass classification, which is one of most suitable methods of stability assessment of active rock slides, was attempted by the authors at Lukuvir rock slide in Darjeeling Himalaya, India. Mapping of the affected slope brought out three discernable micro-zones such as i) a prominent old rock slide with a few recent minor slide scars (Zone-I), ii) an old rock slide zone with prominent old slide scar (Zone-II) and iii) a prominent active rock slide zone (Zone-III) and their fundamental inputs like slope morphometry, type of materials, probable failure surface, past landslide movements & their failure modes/ mechanisms, hydrological situation, anthropogenic interferences and land cover for each delineated micro zones. Rock mass classification in each delineated micro zones quantitatively determined the lithological and structural anisotropy of the rock mass; its weathering and geometric relation to topography for detailed assessment of quantified rock slope stability and their probabilistic estimate on rock slope failure.

RMR (Rock Mass Rating) and SMR (Slope Mass Rating) classification systems of Beiniawski (1973) and (Romana, 1985) was applied for in the slope formed by thinly banded and jointed quartzo feldspathic gneiss with occasional patches of highly weathered meta-pelitic schist. Consequently shear parameters were estimated following empirical calculation proposed by Beiniawski (1979). After determining SMR, both probability of failure (Romana, 1985) and modes of rock failures were determined in each delineated micro-zone. RMR and SMR values across Lukuvir indicated presence of good rock mass with a probability of failure value of 0.2 in Zone I. The rock mass condition similarly estimated for Zone II and III found to be normal to partially stable with corresponding probability of failure value 0.4. Failure mode analysis considering the joints disposition in the rock, the topography and estimated Ø from RMR indicated that toppling could be the most probable failure mode in Zone-1, whereas in zone II and III wedge failure is the evident failure mode.

These map information brought out will be useful for the planners about the nature of methods to be adopted for the stability of the failed slope and also for designing various protective structures.

A2/35

Landslide Susceptibility studies of Satluj and Spiti River Basin, Dist Kinnaur, Himachal Pradesh using Remote Sensing and GIS

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Abstract

Himalayas are one of the most fragile ecosystems and this fragility is due to its geological history of evolution and structural set-up of the rocks. Landslides are natural phenomenons that are responsible for severe damage to both life and property every year in the Satluj and Spiti River basin of District Kinnaur, Himachal Pradesh. The lithounits consists of soft meta-sediments of Vaikrita and Haimanta Group. An attempt has been made to classify the area into zones depending upon the degree of hazard associated with landslides, using remote sensing and GIS techniques. Six thematic data layers i.e. lithology, structures, slope, aspect, drainage and Land Use Land Cover pertaining to causative factors of study area along with landslide inventory map were used to prepare a Landslide Hazard Zonation Map. This method utilizes the number of landslides pixels in a particular category to calculate a score factor. The score factors were overlaid and using success ratio method the area was classified into 5 hazard zones i.e. Very High Hazard (VHH), High Hazard (HH), Medium Hazard (MH), Low Hazard (LH) and Very Low Hazard (VLH). According to the model, 13 % of area falls into VHH, 22 % of the area falls into HH and 18% of area falls into LH. The weak litho-units of Calcareous Sandstones, Grey Shales, and Gneiss have a high correlation with landslides density. The landslides appear to have a direct relation with structural buffers. The slope and aspect also have a relation with landslides density, wherein the slopes in the range of $35^{o} – 45^{o}$ and the aspect direction of Southeast to southwest have the highest landslide density. According to the LHZ model, 69 % of the observed landslides fall into 13 % of Very High Hazard, whereas 20 % of observed landslides fall in 21 % of High Hazard, on the other hand, only 6 % of the observed landslides fall into 30 % of Medium Hazard.

Integration of Indigenous Methods of Landslide Risk Reduction into National Disaster Management Framework

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Abstract

Even before we came up with high technology based early warning systems, or standard operating procedures for response, numerous local communities worldwide have prepared, operated, acted, and responded to natural disasters using indigenous methods passed on from one generation to the next. Indigenous knowledge is culture specific, and represents people's lifestyle. Indigenous knowledge refers to the methods and practices developed by a group of people from an advanced understanding of the local environment, which has formed over numerous generations of habitation. The local people observe signs in the environment which allow them to take precautions before a disaster occurs. This knowledge contains several other important characteristics which distinguish it from other types of knowledge. These include originating within the community, maintaining a non-formal means of dissemination, collectively owned, developed over several generations and subject to adaptation, and imbedded in a community's way of life as a means of survival.

Darjeeling, situated in extreme north of West Bengal, is prone to landslides, due to topography, unplanned development and rapid population growth, among other causes. Communities have a large and diverse body of knowledge on disaster mitigation based on traditional wisdom. Since they live in remote, isolated and inaccessible hamlets on the ridges or on the foothills, they have their own coping strategies in times of disaster. As a result, many remote and isolated communities have made use of different indigenous mitigation and preparedness practices to minimize the negative impacts of disasters to life and property. Landslide hazard can be reduced if tackled at the appropriate spatial and institutional scales. If stakeholder engagement - from communities to governments - is enabled, the implementation of 'on the ground' risk reduction to effectively reduce landslide hazard is possible.
This article directly addresses these issues by developing an approach to integrate indigenous knowledge into Disaster Risk Reduction framework of the country.

A2/37

Incidences of Slope Movement and Need for Monitoring the Slopes above the RIM of Tehri Reservoir, Tehri Dam Project, Uttarakhand

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Abstract

The issues pertaining to the stability of reservoir slopes are of paramount importance for any mega hydropower project. Instability of the reservoir slopes has a direct bearing on following i) scheduled commissioning of the project, safety of the populace in the reservoir periphery and in downstream stretches and iii) safety of the dam and appurtenant structures.

A giant reservoir, extending 42 Km along Bhagirathi and 25 Km along Bhilangana rivers, is progressively getting filled after the completion of 246.2m high earth and rock fill dam at Tehri across Bhagirathi River, in Uttarakhand Himalaya. The gross and live storage of the reservoir will be 3540 million m^3 and 2615 million m^3 respectively.

Detailed geological studies of the left bank slopes (of Bhagirathi river) during late eighties and in early 2000 revealed signatures of ground movement in the form of active land slide, tensional cracks and subsidence on the ground. Small tension cracks and evidences of ground creep, commonly observed up to about 150m above the reservoir level in nearly dry slopes, indicated onset of instability. Large tension cracks and sinking ground conditions in areas close to HFL suggested that considerable horizontal and vertical movement have occurred. Evidences of head ward retreat of prominent slide zones above HFL were recorded in overburden covered slopes.

With the closure of last diversion tunnel on 29th October 2005, the reservoir has been filled gradually to different levels (i.e. El ± 780m, El ± 815m & El ± 820m) and its effect on slopes is also clearly visible. During the very first three seasons of filling and subsequent draw down a number incidences of slope movement have been identified on the left bank slopes of Bhagirathi and right bank slopes of Bhilangana rivers. It thus calls for immediate attention for monitoring of the slopes above the rim of reservoir along both the tributary streams.

In this regard GSI has started some investigations involving remote sensing technique and also systematic geological mapping of the reservoir rim area. However the use of latest techniques like Ground Based Synthetic Aperture Radar Interferometry (GBSAR) or Slope stability radar (SSR) along with a network of Global Positioning System (GPS), instruments for measuring surface and subsurface deformations may be a fast and effective alternative.

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A2/38

Assessment of Landslide Hazards in Parts of Sikkim Himalaya, India

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Abstract

Hazards due to landslides and mass movements are the common phenomenon in mountain realm like the Sikkim Himalaya. In the recent year a large number of landslides cause extensive damages to the roads, buildings, forests and agricultural fields in many parts of the state. The main reason for this phenomenon is attributed to the geological set up of the area combined with heavy rainfall and man made activities. Apart from this, recent developmental activities, particularly road construction and ill planned settlements, have further aggravated the incidence of landslides and sinking. The occurrence of these hazards can not be prevented but their impact can be minimized if the effective measures are taken to reduce their severity, frequency and magnitude. In order to keep the environmental degradation to minimum due to developmental activities, it is essential to identify hazards prone zones in hilly terrain.

The present study area is located in parts of South District of Sikkim Himalaya, is separated by Teesta and Rangit rivers. This study aims to carryout detailed geological, geomorphological and hydrological field investigations of hill slope instability and the impacts of landslides over a typical hard rock terrain of this region. The developmental activity has affected the hill slopes adjoining the road section at a number of places by various types of slope movements, particularly debris slide, debris flows and rock slide. A detailed field investigation has been done with a view to asses the nature, type and mode of failures, geological setting, structural features, geomorphological features and causative factors along the seven major routes in parts of south Sikkim and its surrounding region. In these routes, a total of about 48 locations of slope failures have been identified. It has been observed that more than 50% of the landslides are of rock cum debris slides this is mainly due to the large area covered by quartzite, phyllite rock types in the area.

A2/39

Landslide Hazard in Kashmir Himalaya: Geological control and Human Action

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Abstract

Himalaya is geodynamically very active area. Due to high relief and active uplift, the rate of natural erosion is expected to be high. In addition, unconsolidated Quaternary sediments, folded, faulted and fractured nature of rocks compounded by intense rainfall make most of the Himalayan river valleys susceptible to erosion and landslides. Kashmir basin, one of the longitudinal tectonic valleys of the Himalayan mountain range is constantly faced with landslide hazard. In Kashmir Himalaya, landslides have been continuing since pre-historic times. Besides the recent Baramula (2008), Anantnag (2008), Valtango avalanche (2005), Lower Munda (1996), major occurrences of landslide include near Khadanyar (Baramulla, 844 A.D.), Hassanpur-Hussainpur (1555 A.D.), Khadenyar (1885) etc. Thus we can see the Kashmir Valley is enough prone to landslides. The study shows that these events occurred mostly in combination with other natural phenomena like, earthquakes, floods, snowfall, and rainfall.

Continuous increase in human activity has increased the human pressures which inurn has increased the incidence of landsliding. The resulting landscape characteristics also influence the nature and intensity of human activity.

Database generated through such study would, as a spin off, enable to develop hazard zonnation map and a reliable prediction model for the entire Kashmir Himalaya based on the geological control and human actions associated with it.

Natural Hazard Scenario in Kashmir Valley: New Insights and Research Directions

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Abstract

Geological, geomorphological and hydrological factors make the river valleys advantageous for human habitation. However, often these factors make them equally vulnerable to natural hazards. A striking example is the Kashmir Valley located in the NW Himalaya, where 5.5 billion people live in areas prone to destructive though moderate earthquakes, devastating floods and uncontrollable landslides/avalanches. In the course of our recent search for natural hazard events in Kashmir Valley many of the hydro-meterogical and geological hazards and other intriguing problems were highlighted.

Among the natural hazards, occurrence of cloudbursts and flash floods is most common natural hazard in Kashmir Valley, owing to its peculiar geomorphic conditions accentuated by the hydro-meteorological perturbations over the peripheral ridges causing inundation to the low lying areas of the Valley. Studies have indicated that the impact of cloudburst and demage to life and property is much more severe in the area of occurrence than in the areas outside its influence. Instances of landslides and avalanches, some of them disastrous, have also been observed in the incoherent Quaternary material. The study shows that the landslide events occurred mostly in combination with other natural phenomena like, earthquakes, floods, snowfall, torrential rainfall, compounded by anthropogenic activities. Earthquake occurrence seems to be low as compared to hydro-meteorological and landslide hazard. A few of them (earthquakes) caused severe demage to life and property and were associated with crustal deformations and long periods of aftershocks. Srinagar and north Kashmir appear to have been repeatedly and severely affected by most of the earthquakes.

The database, thus, generated will help in understanding the nature, mechanism and causes of natural hazards and also highlights the need for new insights and research directions. An understanding of the natural hazards in Kashmir Valley can help to deduce the cyclicity of these events, and can help guide regional design and planning in natural hazard mitigation.

A2/41

An Attempt to Estimate the Stress of Caisson Pile With Kaiser Effect

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Abstract

In Washiodake landslide located in Nagasaki Prefecture, caisson piles are installed to prevent landslide movement. The stress of reinforcing rod in the caisson piles have been monitored by strainmeter for more than 15 years since they were first installed. Recently, the strainmeter began submitting abnormal values due to the long-term usage. Therefore, it is necessary to estimate the stress applied in caisson piles by methods other than reinforcing rod strainmeter. First, precedent compression stress of a concrete core was evaluated using AE method (Kaiser Effect). Meanwhile current present stress state of a caisson pile was evaluated. According to the estimation, the values they were within tolerance.

A2/42

Man-made geological disasters in Bulgaria

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Abstract

Very often the recent evolution of the civilization in the world including in our country is related to considerable changes in the geological environment. The effects of the changes could be obtained in short- or long-time periods. A part of the changes in the geological conditions provokes disasters in short-time periods – muddy flows, man-made earthquakes, landslides, rockfalls, land subsidences etc. The study of the short-time geological disasters manifested as a result man-made actions is made for the better protection of the people, their constructions and the geological environment.

A2/43

Rainfall-induced landslide hazard assessment and early warning for Nepal

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Abstract

In Nepal, people live in widely spread settlements and suffer more from landslides than from any other type of natural disaster. Owing to the rugged topography, the complex geological structures; the fragile soil cover, the high intensity monsoon rainfall, the large temperature variations, and the occurrence of very large magnitude earthquake events, natural phenomena such as landslides, debris flows, soil erosion, and other mass wasting processes occur very frequently in Nepal. As such they are the primary cause of environmental degradation in the Himalayan Region. Every year, especially during the summer monsoon periods, many lives are lost and tremendous damage occurs to property, infrastructure, and the environment of Nepal as a result of landslides and related natural events. The intense summer monsoons are the main factor in triggering landslides. A large number of human settlements in Nepal are situated either on old landslide masses or in landslide-prone areas. As a result, a great number of people are affected by large- and small-scale landslides throughout Nepal, especially during periods of monsoon rainfall. So, landslide hazard assessment needs to be considered as main component of development on mountain slopes. This paper exclusively describes science of landslide hazard zonation for rainfall-induced landslides with some case studies and proposes prototype landslide hazard maps. The accuracy of the landslide hazard zonation map was evaluated by various techniques, including area under the curve, success rate and prediction rate. The resulting landslide hazard value calculated from the old landslide data showed greater than 80% prediction accuracy. The analysis suggests that geomorphology-based and human intervention-related causative factors have significant roles in the variance of the probability value in comparison to geology-related factors.

Similarly, this paper will also highlight a prototype early warning system for rainfall-induced landslide integrated with landslide hazard maps. Relationships between landslide occurrence and rainfall characteristics, i.e. rainfall threshold for landsliding in the form of empirical equations are used to prepare two models of early warning systems (RIEWS and N-RIEWS). The findings of this research will certainly help to reduce landslides calamities in villages and cities of Nepalese Himalayan slopes and it will certainly assist sustainable development projects of Nepal with limited environment degradation issues.

A2/44

Avalanche Hazard Mitigation using Formation Zone Control Structures

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Abstract:

Avalanche hazard can be mitigated by retaining barriers in the formation zone. These barriers in the form of Snow bridges, Snow nets and Snow rakes are installed on an inclined terrain having slope between 30^0-50^0 with a view to support, sustain or retain the snow mass. These are erected in the vicinity of highest fracture lines that were observed or expected. SASE has designed, developed and erected these formation zone control structures at D-10 experimental site along Jammu-Srinagar National Highway-1A (J&K) which is located in the *Pir Panjal* ranges of the Western Himalayas.

A well planned avalanche control programme integrating the avalanche forecasting, artificial triggering and structural control methods is the need of hour to provide maximum protection at a reasonable cost. The first step in an avalanche control measure is to assess the magnitude of the problem through a registration of avalanche sites. Registration of avalanches, which is the first step in planning an avalanche control scheme commenced way back in 1974 on either side of Jawahar tunnel.

The paper deals with the planning of formation zone avalanche control structures in the mitigation of avalanche hazard.

A2/45

Using GIS and Virtual Reality for Avalanche Hazard Management

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Abstract

The avalanche occurrence in northern Indian Mountains draws significance because of strategic reasons and tourism. It poses serious problems for the military movements. Traversing these rugged and hostile snow bound avalanche prone regions in winters necessitate reliable avalanche forecasting and complete prior knowledge of the terrain. This in turn requires computer models to aid the troops in interpreting the terrain before actually being deployed there.

In order to be able to have a better overview of the avalanche situation, Geographical Information System (GIS) has been used such that spatial analysis can be done on the snow and meteorological conditions leading up to an avalanche. Virtual Reality tools are being used for 3-D Stereoscopic terrain visualization of the snow bound mountainous areas. It is used as a training tool to familiarize personals with the nuances of negotiating harsh and hazardous terrains. It can also be utilized for avalanche rescue mission planning.

Taking advantage of high quality digital terrain models within GIS and combining the results with perspective three-dimensional spatial presentation, it is now feasible to enhance hazard mapping with dynamic components. Main data input required is high resolution digital elevation models. Using GIS software, this data is derived into topographic parameters like slope angle and aspect etc. Satellite imageries are used to derive other parameters like forest cover etc. With these layers of information, a topographic analysis of avalanche sites is done and the weightage factors are derived from the critical values of terrain parameters for defining the hazard level of avalanche sites.

Virtual Reality tools are being used for 3-D Stereoscopic terrain visualization of the snow bound mountainous areas. Geo-referenced satellite images of summer and winter months are draped over the terrain model to provide realistic visualization. Synthetic terrain surface is generated based on high resolution satellite imageries with rendering of non-terrain objects such as trees, buildings, rivers etc. to give an observer a frame of reference of the real world. Fly-through of these terrain models are made along predefined flight paths, which can be visualized in 3D Stereoscopic mode using LCD Shutter Glasses in active stereo mode. These can be projected in stereo mode on polarized filters based LCD projector.

Keeping all this in view, GIS together with the virtual reality environment is a very useful tool for avalanche hazard management.

Avalanche Disaster Mitigation In Western Himalaya

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Abstract

Snow avalanches pose grave threat to precious lives of civil and military personnel besides potential of damage worth millions in snow bound regions of Western Himalaya. Remoteness of area, inhospitable terrain, extremely cold climate, persistent bad weather conditions and poor communication facilities are some of the serious impediments in avalanche disaster management in the area. However, Snow & Avalanche Study Establishment (SASE) is committed to mitigate the avalanche hazard in Indian Himalaya. Detailed area mapping has been conducted and archived in print form as well as in GIS environment. Extensive network of manual observatories, Automatic Weather Stations (AWS), Upper Air Stations (UAS) and Doppler Radars has been set up to collect snow-meteorological and avalanche related data on daily basis. Many active and passive methods have been developed to mitigate the danger. The preferred methods for the mitigation of the hazard remain to be structural control and artificial release of avalanches (active methods), though it may have some economic and ecological implications in addition to practical limitations. Avalanche forecasting (passive method) is most widely practiced method. Also, efforts are on to generate awareness among troops and civilians with respect to safe conduct in avalanche prone areas.

With the above, co-ordinated avalanche disaster management and information access scheme has been prepared by integrating different communication links and applications. The paper explains the above in detail, brings out the major challenges being faced and suggest future line of action in view of the recent technological advancements.

A2/47

Measurement of snow wetness using TDR: An indicator of snowpack stability

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Abstract

Most of the late winter avalanche activities in the North – West Himalaya are observed due to introduction of the melt water in the snow, generation of the melt causes large variation in the snow strength. The presence of snowmelt reduces the cohesion between the various snow grains and introduces heterogeneity (MF/ice layers and ice lens) in it. The phenomenon of the wet snow avalanches is not yet completely understood, as the melt water generation and its percolation within the snowpack is very complex. Monitoring of liquid water content of snow helps in understanding the stability status of snow pack to a greater extent. This study presents experimental investigation of liquid water content (LWC) in the snow pack at Patsio research station, located in Great Himalayan range, for winter seasons 2006-07 and 2007-08. Time series measurements of LWC were made using the Time Domain Reflectometry (TDR). The experimental setup for measurement of dielectric constant of snow consists of set of TDR probes inserted into the snow pack at different heights. The measured dielectric values of snow were used for the estimation of LWC. Study reveals that dielectric constant of the snow show a gradual increase in the early to mid winter, as during this period snow conditions were dry, because of low ambient temperatures. This gradual increase in the dielectric constant was related with the compaction of the snow cover and increase in the density. In the late winter very large diurnal fluctuations of the dielectric constants were observed. These fluctuations were mainly due to the melting of the snow at and near snow surface and its subsequent percolation into the snowpack. The ambient and snow surface temperature data was used for further analysis and validation of the results. The information can be used to assess the snowpack for qualitative avalanche forecasting during late winter.

A2/48

Composite Avalanche Control Scheme Using Formation Zone Structure at National Highway -1A

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Abstract

Avalanches are one of the major natural hazard which takes its toll in terms of human, properties such as communication line, highway, etc, every year in snow bound areas of Himalayan ranges especially in western states of J&K, HP and Uttaranchal state of india. These avalanches can controlled by way of installation of avalanche control structures on mountain slope, avalanche forecasting and controlled release of avalanches.

NH-1A highway is strategically important and busy highway, crossing in avalanches prone snow bound area between Naugaun (km 200) and lowermunda (km 215) from Jammu. This highway is lifeline for civil and defence population and crosses through 15 avalanche sites called D-1 to D-15. The highway was frequently blocked by debris from these avalanche sites during winters. The D-10 avalanche site is most frequent avalanche site. A comprehensive composite scheme comprising supporting structures, wind drift control structures and controlled release of avalanches has been designed and implemented at the D-10 experimental avalanche site on this highway. This site has a large catchment area with 12 gullies. This paper describes the composite avalanche control scheme designed to control the D-10 avalanche.

Technical Survey of Various Artificial Triggering Systems

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Abstract

An avalanche is a sudden downward motion of the snow mass along the mountain slopes which may contains rocks, trees, boulders etc. Snow avalanche hazards are one of the most challenging threats in the snow bound regions. The avalanche hazard depends on the evolution pattern of snow pack and the amount of snow received, besides other geomorphologic parameters of a region. Apart from occasional variations, the number of avalanches over a period does not increase. It is rather an increase in a number of risk-exposed people due to the rapid development of traffic and winter activities in these areas that concerns us. At the same time human society is becoming more and more demanding with respect to personal safety, hindrance free transportation, uninterrupted communication etc., which normally gets affected due to avalanche activities. Further due to certain constraints, many of the man made structures like transmission lines, rails, dams, roads and research stations etc. are sometimes placed in unsafe locations or have an unsafe approach which may result in a disaster and in danger human life and works too.

To reduce the avalanche hazards there are several techniques and are divided into active and passive methods. Installation of avalanche control structures, drift control structures, snow gallery, retarding structures are the techniques comes under the passive methods and are long term preventive measures which consumes money as well as time. Avalanche forecasting and artificial triggering are the foremost techniques under active methods are used as short term preventive measures. Out of these avalanche forecasting is all dependent on the field data and record of the location which require physical presence of technical people and meteorological observatory instruments in the area of interest. But the direct action method is artificial triggering method which is control release of avalanche using explosives/gases. In this method potential zones of avalanches are released in small parts under controlled condition and predetermined time to reduce the exposure of persons and materials resulting reduction in risk. In this operation the site is identified where the snow deposition is much and can endanger the valley. The valley movements are stopped and avalanches are triggered with the help of explosives or other means manually, electronically, mechanically. The essential thing is to cause initial breaks by setting off artificial tremors (blasts). These will sufficiently reduce the stability of the snow cover to produce a snow-slip. Blasting is especially suitable for releasing avalanches on steep slopes. It is usually possible to detach small sections of snow at intervals and thus avoid major avalanches, which take a long distance to run their course and can be extremely destructive. However, it is essential that the blasting operations be carried out at any time of day and in all types of weather.

This paper describes the various techniques of artificial triggering being used globally.

A2/50

Identification and Mapping of Snow Avalanche Hazard Areas for Disaster Management of NW-Himalaya using Remote Sensing & GIS

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Snow avalanches are one of the major hazards in NW-Himalaya. This affects the development in mountains, winter recreational facilities, army deployed in these areas, road/tracks, utilities and communication setup. The increasing toll of lives and loss of properties in snow bound regions require the attention for identification & mapping of avalanche hazard areas and its compilation in the form of latest information, speedy generation, updation and economic to support planner and decision makers to headway the sustainable development strategies. Since, the conventional techniques are time consuming, very expensive, difficult for the hostile conditions and non-availability of the latest edition of topographic maps.

In the present paper avalanche hazard areas are identified, mapped and digital avalanche atlas is generated using satellite remote sensing and GIS for the NW Himalaya. The topographic characteristics are analyzed using digital terrain model (DTM) and ancillary data for the identification and mapping avalanche hazard areas. The designed digital avalanche atlas consists the complete information of each avalanche site (map reference, distance, area, altitude, slope, aspect, ground cover, effect on highway/track, suggested control measures, avalanche occurrences and user's guide). The detail of each avalanche sites also includes L-section, track profile and position of track reference to distance and avalanche zones respectively. It also includes general information of the area, avalanche formation and its contributory factors, control measures, safety & rescue measures. The atlas also has the wider selection criteria based on map ref, distance, altitude, slope, aspect etc. to retrieve the information of specific avalanche sites for effective decision-making. The atlas is user-friendly, password protected along with updating facility for authorized person. All the above information is very important for the decision makers for taking necessary measures for avalanche hazard mitigation.

Key words: Snow avalanche, Avalanche hazard, Digital avalanche atlas, GIS.

A2/51

Geomatics Techniques for Avalanche Information System of NW-Himalaya

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Avalanches are the major hazards in snowbound areas, caused by the terrain, snowcover and meteorological parameters. It is difficult to obtain avalanche hazard information of remote areas, using ground conventional techniques, which have several limitations and time consuming. Airborne hyperspectral imaging, spectroradiometer, LiDAR, digital photogrammetry and ground penetrating radar (GPR) are proven useful techniques for snow and glacier studies. In this paper, the present status and future scenario of the Geomatics techniques are discussed for avalanche information system of NW-Himalaya. Airborne LiDAR and digital photogrammetry survey helps in generating the latest, high resolution terrain information and also allows us to monitor the evolution of snowcover processes. Snowcover characteristics can be estimated using hyperspectral imaging, which also helps in evolution of snowpack and information of avalanches hazard areas. These systems can also be used for the avalanche activities of remote areas and to assess the extent of avalanche occurred.

Presently, we have studied the snowcover characteristics using spectroradiometer, which can be used to identify fresh snow, metamorphosed snow, contaminated snow, patchy snow, snow mixed with vegetation and snow grain size, using hyperspectral images. The snow depth and buried objects under snow signatures were collected using airborne GPR, and the results obtained were found to be in good agreement with the ground observations. Spectral signatures of different type of avalanches are collected and it was found that the avalanche activity can be observed using hyperspectral images together with the signatures collected from airborne GPR. These instruments can be used to find the details of avalanche, like debris volume and buried objects under avalanches. This study can be helpful in understanding the potential of above technology for avalanche hazard and can provide vital inputs for improving the operational avalanche forecasting as well as for strategic planning.

Unmanned Aerial Vehicles For Monitoring Of Avalanche Disasters

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Abstract

An Avalanche is an abrupt and rapid flow of snow mixed with air and water along the mountainside and is one of the biggest disasters in mountainous terrains to life and property. An UAV is an unpiloted aircraft either remotely controlled or fly autonomously based on pre-programmed flight plans. Hence UAVs are totally dependent on the robustness of the entire system.

The UAVs are designed based on two major aspects viz. performance aspects and mission aspects. However the design of a UAV for monitoring the avalanche disaster takes in account the performance as well as the mission of the UAS. This is mainly because of the operational constraints at high altitudes. It has been observed that the performance of an Unmanned Aerial Vehicle (UAV) degrades exponentially with increasing altitude. Hence, emphasis has been laid on the operational constraints that need to be addressed during the initial phases of design. Short takeoff and landing (STOL) in unprepared runways with less stall speed and maximum climbing rate are some of the other mission constraints, on which keen attention has been paid during the initial phases of design.

Weight, endurance, range, speed, wing loading and engine used are some of the important parameters that directly influence the performance of the UAV. These particular aircraft operate in near incompressible region i.e. low speed low Reynolds numbers in the range of $0.5x10^6$ to $0.8x10^6$. Such low Reynolds Number behavior of airfoils is characterized by the formation of an extensive laminar separation bubble, on either the upper surface or lower surface or both. This bubble increases drag by altering the effective profile of the airfoil. The laminar boundary layer separates in the process of negotiating the adverse pressure gradient. The higher level of energy and the momentum transfer associated with it many times makes the turbulent shear layer to reattach. The phenomenon of stall hysteresis in lift and moment may occur at high angle of attack operations. Also, since high cruise lift coefficients are desirable and the overall size of the system is highly scaled down as compared to conventional aircrafts, the aerofoil selection and design completely change in this case. Moreover the selection of engine will play a critical role in developing a robust system. Therefore the engines used in such high altitude UAVs are designed in order to sustain freezing conditions during the course of flight. Superchargers are also needed while flying over glaciers as the density comes down with the increase in altitude, which affects the piston engine performance. The optimization for the above parameters is carried out to enhance specific improvements in configuration.

Towards the end, the paper also briefly looks into the various sensors to be mounted as payload, the fabrication and maintainability issues that are dealt with during the final design stages of the UAV.

Exploration Of Underground Strata Using Ground Penetrating Radar Near Khardungla Top (J & K)

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Abstract

Khardungla pass is strategically important to India as it is used to carry essential supplies to Siachen. The road Leh-Khardungla-Deshkit linking Leh with Nubra valley passes through the Ladakh ranges, scaling the Khardungla pass(34°16′44″N, 77°36′17″E) at a height of 18,380 feet. The present study focused primarily on some part of the route from the Khardungla top to the north pullu location, while moving towards the Nubra Valley (Indian Himalaya). Where very heavy land slide and snow avalanches constitutes a potential hazard to people safety and thus also affects the road traffic.

Ground penetrating radar (GPR) has been used to investigate the soil strata of different avalanche paths near Khardungla top as GPR provides continuous subsurface information in a rapid and economical fashion, with the potential for significant cost saving compared to digging enough test pits to fully characterize the site.. GPR (Mala Geoscience) of frequencies 50, 250 and 500 MHz was used for the survey. GPR profiling was carried out in reflection mode and the time window was decided on the basis of the required depth of penetration. Soil strata information of top few meters was gathered using 250 and 500 MHz frequency antenna, while 50 MHz was mainly used to detect the bedrock.

Dielectric constant is an important parameter for GPR surveys as it controls propagation velocity of electromagnetic waves through material. Dielectric constant of rocks and sediments is primarily a function of mineralogy, porosity, pore fluids, frequency and other parameters. However in the present study the dielectric moisture meter is used to estimate the dielectric constant value.

From the radar gram obtained using 250 and 500 MHz antennas at first two avalanche sites, hyperbolic signatures were observed up to 4 m depth, this shows the presence of boulders embedded in the soil up to this depth. Sharp reflections at much higher depth were seen from the radar gram of 50 MHz antenna. However the radar signatures of avalanche site 3 shows the absence of the hyperbolic signatures this may be due to presence of boulders and blocks larger than one wavelength as this attenuates the signal due to scattering and thus reduces the depth of sounding. Thus from the civil engineering point of view this specific site can be utilized for installation of structures.

All the GPR profiles were taken in the longitudinal direction along the road, which is totally broken due to frequent land slide and also as it remains under snow most of the time in a year. Additional information from bore holes is needed if the exact composition of subsurface materials is of interest.

Landslide Studies in NER by GSI

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Abstract

In *I*ndia out of the landslide prone areas, 20% (about 0.098 mill. sq. km.) is located in NER and rest 80% is spread over Himalayas, Nilgiris, Ranchi Plateau, Eastern and Western Ghats. Geological Survey of India, one of the oldest scientific survey organisation in the world, has been engaged in the study of this natural hazard for over 125 years.

The North Eastern Region (NER) comprising seven sister states (viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura) occupies a unique position in the country by its typical geological set up, geomorphological features, seismic activity and precipitation, which make it prone to geological hazards, such as landslide, earthquake and flood etc.

Landslide studies were started in North Eastern Region by Geological Survey of India since 1974. GSI was declared nodal agency for landslides by Govt. of India in 2004. To identify problematic areas , GSI has undertaken studies related to landslide at specific request from State Governments and other organizations, Landslide hazard zonation project, GSI, NER, Shillong is engageged in carrying out following work.

Preparation of Landslide Hazard Zonation Map (LHZM) of NH/SH and important cities/ township:

1. MACRO LEVEL LHZ (1: 50,000 scale)
   - i. Lunglei, Lawngtlai & Saiha districts, Mizoram - 6700 sq. km.
   - ii. Cachar, Assam & Jaintia district, Meghalaya- 1000 sq. km
   - iii. East Khasi Hills and Ribhoi districts, Meghalaya - 500 sq. km.
   - iv. Kolsaib and Aizawl districts, Mizoram- 750 sq. km.
   - v. Kolsaib district, Mizoram and Cachar district, Assam -405 sq. km.
   - vi. Kohima district, Nagaland -200 sq. km.
   - vii. MACRO LEVEL LHZ (1:25,000 scale)
   - i. Itanagar Capital Complex, Arunachal Pradesh-140sq.km
   - ii. Guwahati Urban Complex, Assam-600sq.km
   - iii. Lunglei Area, Mizoram .
2. MESO LEVEL LHZ (1:10,000 scale)
   - i. Serchip, Chiahtiang Townships, Serchip district, Mizoram- 255 sq. km.
   - ii. Lunglei Town, Mizoram
3. MACRO LEVEL LHZ OF NH/ SH (1: 50,000 scale)
   - i. Along NH-40 between Shillong and Phalangpongtung (Dawki), East Khasi Hills district, Meghalaya
   - ii. -200 sq. km.
   - *iii.* Along NH-44 between Shillong (Laitkor) and Khliehriat, East Khasi Hills & Jaintia Hills districts, Meghalaya, - 200 sq. km.
   - iv. B. Detailed Site specific studies of major reported landslides:
   - i. Mao Song, Senapati district, Manipur ,

ii. Serchip, Hmar Veng, Serchip district, Mizoram
iii. Guwahati, Assam,
iv. Kalapahar, Guwahati, Kamrup district, Assam
v. Zubza, Kohima district, Nagaland (Initiated since FS 2008-09)
vi. C. Landslide inventory volume1
vii. incorporates data on landslide occurrences(314nos) of NER up to
viii. FS 2001-02. The second volume is being prepared which will incorporate the landslide incidences from FS 2002-03 to FS 2008-09. In the second volume, a total of 90 landslide incidences have been recorded from all the states of NER.

D. Landslide monitoring:Continuous monitoring of active landslides is being carried out at. Sonapur Landslide, Jaintia Hills district, Meghalaya.

In the light of the studies on landslides vis-à-vis LHZ maps, help the planners and field engineers to demarcate the hazard prone areas and choose favourable areas for developmental activity.

A2/55

Phutse Glacier Lake Out Burst Flood Ladakh Range, Leh Ladakh Jammu and Kashmir

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Abstract

Global surface temperature of earth has been on the rise since the end of the Little Ice Age (15th – 18th centuries). Increased developmental activities in recent times have accelerated the global warming. Glaciers by and large have responded by retreating at a rate that ranges from a few meters to several meters per year. Rapid recession of glaciers is resulting in the formation and increase in the size of glacial lakes, increasing the threat of glacial lake outburst floods (GLOFs). Ladakh Range and Karakoram Range of mountains in Ladakh District has witnessed several GLOFs in past but very few have been documented, except the bursting of glacial lake formed by the blocking of Shyok River by the surging Chong Kumdan glacier in 1930s. This is one of the best-documented and monitored GLOF of Ladakh.

Occurrences of GLOFs in Ladakh Range have not received due attention of scientific community. GLOFs have been recorded as flash floods in district revenue records. It is only on closer examination and detailed field investigations many of the flash floods are typical cases of GLOF. In the recent past flash floods have been attributed to cloud bursts, there are field evidences, which clearly indicated that some of these were in fact GIOFs. There is a need to differentiate between the two, especially when the occurrences of cloudbursts have increased in the recent past in the region.

On closer examination of satellite imageries of Ladakh it is observed that there are number of small glaciers and ice fields in catchments of every small stream flowing down the slopes of Ladakh range which may or may not join Indus or Shyok river depending upon the amount of water in the stream (Tokpo in Ladakhi). The significant feature associated with most of these glaciers is the development of recessional terminal moraines and glacial lakes that are either drained in pasts or are in processes of formation. In the past recessional glacial lake formation was larger and the magnitude of floods in the Tokpos was also much more than at present when the size of the glaciers where much larger. This is clearly evident by the size of boulder spread over the alluvial fans of these tokpos. Breached terminal moraines bear witness to the bursting of recessional lakes in the headwaters of many valleys of Ladakh range.

Preliminary examinations of flash floods in Leh and Phayang Tokpo in Agust 2006 were carried out in the summer of 2007 and 2009 by authors. In course of fieldwork it was observed that the floods in Leh and Phayang Tokpo were due to the bursting of recessional glacial lakes. Phutse glacial lake in the headwaters of Leh valley, breached in August 2006. Field evidences indicate that the breaching of moraine dam occurred with the melting of ice core. Increase in the summer precipitation substantially contributed to increase in the water level of the lake and subsequent bursting of the lake. The increase of atmospheric temperature played a major role in formation of lake by way of enhanced surface melting of glacier over a height of 5000masl. An important factor, which has not been given its due importance, is the melting of the permafrost with the increase in global temperature. This is not only destabilizing the mountain slopes but also contributing to increase of melt water flow into glacial lakes.

There is an urgent need for the preparation of inventory of the glacial lakes of Ladakh and to identify potentially dangerous glacial lakes. Developing a monitoring and early warning system to forewarn the dangers of GLOF in advance to the people living down stream.

Glacial melt water has been the source of sustenance for the people of Ladakh since the time of early settlers in Ladakh. Glaciers have already receded to such an extent that it would be difficult in coming days to meet the basic need of water for the people of Ladakh. Depleting glacial melt water would also have its impact on the ground water reserves. Therefore it is suggested that methods be evolved for controlled breaching/draining of recession lakes. Thereby impounded glacial lake water is utilized as sustainable source of water for the people of Ladakh rather than being a cause of destruction

A2/56

Slope Instability Hazard near Lambagar on National Highway-58, District Chamoli, Uttarakhand

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Abstract

The slope instability hazard is a common problem along Rishikesh-Badrinath route (NH-58) in Chamoli district, Uttarakhand. The Lambagar slide zone, near km stone 305.5 on National Highway-58 is one of the major trouble spots affecting the communication network to famous Hindu shrine at Badrinath. The instability hazard has had profound impact on the life and property of commuting public ever since this slide zone became activated in 1998. The July, 2009 breach of the road section is latest example of the threat associated with the slide event. The instability zone, located on right flank of the valley of Alaknanda river measuring about 350m along the road with maximum crown elevation 2280m. The river bed elevation is at2140m. The river flows in a narrow gorge in south-south east to southerly direction and then takes southeasterly turn near the slide zone. The slide zone is confined between two prominent streams that join river Alaknanda from the right flank.

The slope forming material of the slide zone comprises highly assorted boulders/blocks of gneisses, quartzite, phyllite etc. embedded in sandy matrix, indicating it to dominating by morainic material with subordinate ingredients of fluvial material. Such material is characterized by in-consistency in terms of cohesion and binding capacity. The geo-mechanical tests of the slide material indicate that they are generally non-plastic, compact with dry density 1.9gm/cc, low cohesion (0.08gm/cc) and has high angle of internal friction of the order of 39°. The environs of the area expose massive quartzite belonging to Central Crystalline Group. Geological mapping of the slide zone identified different active slides, areas of gully erosion, vegetative cover and other natural and cultural features.

The slide has been categorized into different zones each representing distinct characters of slope forming material and slide dynamics. The area above the slide zone *i.e.* just above the elevation 2280m, is a flatter ground marked by number of break in slopes, tension cracks, tilted trees etc. The zone between elevation 2250m and 2280m is the zone of depletion of material and active sliding showing retrogressive movement of the slide area. The high risk zone is the zone of accumulation lying between elevation 2250m and 2140m extending up to the river bed level. It is in this zone that the hazard of fall of material and shooting stones is high. The main factors for failure of the non-cohesive morainic material of the slide zone include gully erosion, deep seated river erosion and enhancement of pore pressure due to infiltration during rains. Preventive measures for the mega slide should aim for protection against slope modifications, construction of flexible support structures and planned drainage network systems in the slide zone area.

A2/57

Research and Assessment on Landslide and Flooding in Mountain Areas of Vietnam by Using Remote Sensing and GIS.

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Abstract

Vietnam located in subtropical zone in The Eastsouth of Asia,characterized by 2/3 mountain area.Based on natural condition, the territory of Vietnam is divided into three parts: the north, the central and the south.The mountain area mainly distributed in the North and the Central Landslide and flooding in the mountain areas often occur in the season of rain and storm. Methodology for conducting the study is Remote sensing with difference kind of satellite data and and GIS technology with integrated spatial analysis models. Results of study can can be assumed as follow :

During the rain season and storm one happen in the same time, the level of landslide hazard become very fierce. Landslide occurs along the high ways, the roads and in the mining of rock exploitation. Research of landside showed that the main reasons of landslide are following:
-Heavy rain concentrates in short time.
-Talus of the roads is high and deep.
-Intensively tectonic deformation.
-Human activities such as opening new roads, improving old roads destroyed stability of slopes and rock exploitation without labor safety measures.

Flooding is serious hazard too. In the last years flooding and flash flooding in the mountain areas often happen in narrow valleys with high landslide potential and bad drain, damaging infrastructure, transport system, agreculture soil and many villages ... caused great loss of property and life.

For mitigating hazard many reengineering measures and removing people to safety areas have been applied.

A2/58

An Overview of National Guidelines on Management of Landslides and Avalanches

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Abstract

The paper briefly outlays the context, structure, areas of operation and schedule of activities, strategies and action points of the national guidelines on management of landslides and avalanches issued by National Disaster Management Authority (NDMA), Government of India. It also signifies the need for implementation of these guidelines for preparation of landslides management plans at district, state and national levels. Disaster Management Act 2005 has indicated that NDMA will lay down guidelines, policies and plans at national level to minimize disaster losses/risks.

The main objectives of these guidelines are to institutionalize the landslide hazard mitigation efforts and make the society aware and prepared to take suitable actions to reduce the risks/losses. The guidelines include both regulatory and non-regulatory measures with defined schedules for all proposed activities. It is envisioned that plans and policies for landslides will be formulated and implemented in accordance with these guidelines.

The structure of guidelines has been laid down with nine major areas for systematic and coordinated management of landslides and avalanches. These areas include i) Landslide hazard, vulnerability and risk assessment; ii) Multi-hazard conceptualization; iii) Landslide Remediation Practices; iv) Research and Development, Monitoring and Early Warning; v) Knowledge Network and Management; vi) Training and Capacity Building; vii) Public Awareness and Education; viii) Emergency Preparedness and Response and ix) Regulation and Enforcement.

The strategies for landslides risk treatment is five pronged i.e. i) Treating vulnerable slopes and existing hazardous landslides; ii) Restricting development in landslide prone areas; iii) Preparing codes for excavation, construction and grading; iv) Protecting existing development and v) Monitoring and warning system as well as introducing landslide insurance and compensation.

The paper aims to discuss and disseminate the information about the national guidelines on management of landslides and avalanches with a view to promote its adaptability and implementation of action strategy.

Landslide Hazard Case Study: The dire need for a comprehensive, long term solution to the landslide problem at Chibo - Pashyor villages, Kalimpong, District Darjeeling, W Bengal.

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Abstract

The western face of Kalimpong town, particularly the areas around Chibo and Pashyor village have had a long history of landslides. Surviving residents of Chibo recall the area was severely affected by slides in the June1950 deluge and then it also received a cruel beating in the Oct1968 landslide disaster - which was the worst extreme event to affect this part of the world in living memory. In recent times, natural and more predominant anthropogenic factors have resulted in an increase in the instability of the Chibo- Pashyor belt with landslides occurring more frequently and with more severity resulting in loss of life, farmland and infrastructure.

The main reason for most of the landslides here is without a doubt, the massive scouring and erosion caused by the large number of mountain rivulets (or jhoras) which drain through Chibo – Pashyor. These jhoras have their source at the crest of the hill and many are fed initially by water from natural springs and then by surface run-off rainwater from the rapidly expanding built-up areas and roads above Chibo. These jhoras over the many decades have neither been enlarged to cater for the increased volumes of water flowing in them, nor has any river training been done to reduce the velocity of water. As such, the huge torrents of high velocity water literally plough through and cause much of the damage in this area.

Unfortunately, population in this region has ballooned and now approximately ten thousand or more people inhabit this area. Their primary source of income remains farming and the paddy crop being cultivated in large tracts here maybe only adding to the severity of the landslide problem. The situation in this area is dire with an urgent need to find a comprehensive, long term solution to the landslide problem since instability in this area is likely to destabilize adjoining areas of Kalimpong town.

Furthermore, the prospect of relocating thousands of people in 15-20 years seems too daunting a task.

A2/60

Planning & Design of Houses For Landslide and Earthquake Prone Areas: A Case Study from Garhwal Himalaya, Uttarakhand

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Abstract

Hill areas are susceptible to landslides. Human intervention often aggravates natural balance of an area prone to landslides. Buildings in hilly area areas are generally located on slopes and hill tops with roads along or access the contours to provide access to houses. Large flat grounds and valley bases are left as open spaces for recreational and other non – habitation purposes. Hill sides with less than 30^0 slope in general are considered to be stable as the gradient corresponds to safe angle of repose of slope forming material. Stable slopes steeper than 30^0 with in – situ roack exposure are encountered in hilly terrains. Buildings should be in general located on hill side with not more than 30^0 slope. None residential and / or temporary buildings may be constructed on steeper slopes up to 45^0

The maximum height of cutting in hill slopes is also a very important component. Experience of the authors from past earthquakes e.g. Uttarkashi, Latur, Jabalpur, Chamoli and Bhuj has revealed that the most vulnerable are the settlements and structures which are located in multi – hazard proneness. Implementation of development projects in a systematic way taking into consideration existing instability / stability investigations to evaluate landslide hazard is essential for successful implementation.

The scientific studies reveal that the extent of damage would have been low, if the necessary measures in selection and development for buildings were taken. Suitable control measure can be taken to avoid the effects of disasters. The present paper covers guidelines for selection of sites and development for buildings in hills that are prone to landslides and earthquakes.

Application of Geographic Information System for Seismically unstable Slope Analysis

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Abstract

Landslides are one of the most damaging hazards associated with earthquakes. Predictions of where and under what shaking conditions landslides are most likely to occur are a key element in earthquake hazard assessment.

Permanent displacements over a certain limiting value tend to trigger landslides. The magnitude of this limiting value depends on the mechanism of the slope failure, lithology, slope geometry and earlier slope movements. As per the previous research work displacement of 10 cm. is considered as critical displacement for slope failure.

Displacement-based methods like the *Newmark Integration Procedure for Sliding Rigid Block* developed by Newmark are the most commonly used seismic analysing method for landslides. In this model slope stability is related to the displacements occurring in a slope as a result of increments of time during pwhich the seismic excitation causes the factor of safety (FS) to drop below one. Using Newmark's model, the displacement of a rigid block can be calculated for any base excitation time history if the critical acceleration (A_c) that causes the initiation of slip is known.

California and Jibson methods are popularly used for estimating Newmark type displacement for calculating slope failure in seismic conditions. The reliability of these two methods for seismically induced slope failure has already been checked and published. The displacement map prepared using empirical methods is useful for identifying vulnerable areas in terms of occurrence of landslides and therefore also useful in implementing landslide preventing measures.

The empirical method for displacement estimation is used in Geographic Information System (GIS) environment for slope displacement map preparation that shows the change in displacement pattern over the area at defined grid size. Arc GIS is an excellent software that is used to convert the material properties assigned to each of the geological units into layers of raster data set with 10-m cell size. The raster data layers are then used to compute the factor of safety, the critical acceleration, yield seismic coefficient, duration and peak demand coefficient for all soil slope for given slope angle. The prepared data layers are used in California method for displacement map generation.

A2/62

Assessment of Causative Factors of Landslide in Sikkim Himalaya and Their Control Measures

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Abstract

Landslides are common disaster phenomena in many countries causing great economic and environmental losses. The Sikkim Himalaya in IHR is known to be one of the most severely affected area. Even a glance at landslide statistics gives some idea of the enormity of damage done and the ever present threat to lives and property. It has been observed that even 50 mm of rainfall in an hour would cause landslips. Unauthorized structures in the unsafe zones, absence of an adequate drainage system and unplanned growth of settlements have accelerated the process of ecological imbalance. In recognition of the acuteness of problems related to landslides, this paper summarizes our knowledge of slope stability so as to provide information on the origin of slope movements and the methods of their investigation, prevention and control. A case study in the Sikkim Himalayas have been undertaken to provide a better understanding of this acute natural disaster problem. Land slide is one of the devastating phenomena in Sikkim Himalaya. Landslides and other mass movements are serious geo-environmental hazards in the Sikkim Himalayas. Massive landslides killing hundreds of people with catastrophic damages have occurred in the Eastern Himalayan State of Sikkim, which shares common borders with Tibet, Nepal, and Bhutan. This paper describes the investigations carried out an old and recent landslide in Sikkim Himalaya, with emphasis on the triggering mechanisms that have contributed to the release and creep of natural slopes in the region. It is believed that the intense rainfall in the region not only contributes to rapid erosion and weathering of the rock mass, but also increases the groundwater level that leads to reduction in the stability of natural slopes. Landslides and slope instability problems are quite common in Sikkim Himalaya. Recent developmental activities in this region have aggravated the incidence of landslides to a great extent. The identified conditioning factors include adverse rock types (mica schist, phyllite, and granitic gneiss and calc schist), multiple joint sets, active tectonism, and very high annual precipitation. The triggering factors are mainly rapid pore pressure built up, seismic activity and anthropogenic interference with multiple control measures the expansion and triggering of slides could be minimized.

A2/63

Role of Rainfall in Inducing Landslides-A Case Study of Vaishnodevi Area, Jammu & Kashmir

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Abstract

Landslides are very common and recurring phenomenon in the Vaishnodevi area, Udhampur district, Jammu & Kashmir. Most often they are triggered by rains on the slopes which are modified by anthropogenic activities in the process of new track construction along the Bhawan route. Such slopes are steeply cut and left overhanging thereby making them more susceptible to future instability. Landslide study in an around Vaishnodevi area covering an area of approx. 25 sq km was carried out for the first time on the basis of Modified Burea of Indian Standards (BIS) method on 1:10,000 scale. The study area mainly belongs to the Trikuta Hills of Sirban Group exposed in the Outer Himalayas, in a series of WNW-ESE trending linear inliers within Murree Group and Siwalik Group of rocks. The main rocks exposed in the area are dolomite, cherty dolomite and stromatolitic limestone/dolomite. The general strike of beds is WNW-ESE with dip varying from 40°-60° northerly.

The mechanism of slope failure need to be understood better, during intense rainfall period as the pore water pressure increases, thereby enhancing the hydrostatic pressure on the surfacial material. The actual pressures that develop in the slope are a function of the soil type and net surface infiltration rate; which itself is a function of rainfall, evaporation and transpiration. The rainfall intensity and variation varies with space, elevation, altitude and duration.

Rainfall plays an important role in inducing landslides in Vaishnodevi area specially in the higher reaches along the track route from Ardhkunwari to Bhawan. It was reported that high rainfall of 12th March, 2007 triggered landslides in the area, disrupting movement of pilgrims along the Bhawan route. To understand better the role of rainfall, there is need of more rainfall data recording station/network in the area for developing early warning system and formulation of future management and mitigation strategy to prevent the damage caused by landslides.

The results of this type of analysis can be used to help predict future performance of slopes under a range of adverse climatic conditions.

Geo-Hazard Management around Mirzachowki in Rajmahal Hills, Jharkhand

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Abstract

The physico-chemical parameters like temperature, P_h, dissolved oxygen, ammonia nitrogen, CO_2, CO, and other gaseous emissions are investigated to ascertain the trend on changes in the environmental features in the given area which belongs to the Rajmahal trap region. The occurrences of various geo-hazards are in the proximity of the stone quarries in the study area. These have an apparent impact on the drainage pattern as well as other environmental attributes. The recent occurrence of landslides although sporadic, is influenced by topography, development of lineaments and chemical reaction phenomena.

A2/65

Geological Assessment of Slope Instability Of Landslide Affected Villages in Tehri And Uttarkashi Districts of Uttarakhand

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Abstract

Severe problem of slope instability has been experienced after major landslides, landslips with subsidences and widespread cracks in cultivated terrace slopes at many villages viz. Kandarigaon and Urgani of Bhaisark village, Bhitali Toke of Phart village in Narendranagar Tehsil of district Tehri, and Pilang, Jurab and Saura villages, Siliyan (Jaspur village) and Paduli (Gyansu village) of Dunda and Bhatwari Tehsil of district Uttarkashi, Uttarakhand. The landslides and related subsidences have damaged human settlements, bridge, foot track and cultivated terraces. These landslides have been triggered by over saturation of thick slope wash material/ debris cover resting on precarious slope. The study was carried out with an objective to asses the risk and vulnerability of landslide affected slopes being utilised for human settlements.

Geologically, the area comprises gneiss and schist of Wazri Formation of Central Crystalline Group; quartz - arenite with bands of slate, red and purple phyllite Mandhali Formation of Jaunsar Group; and metabasic and quartzite with interbedded slates and occasional bands of limestone of Uttarkashi Formation of Garhwal Group.

The slides of July-August 2007 and subsequences, activated as result of heavy rain fall when the highly weathered and jointed rocks on steep slopes failed due to the removal of fines and the debris thus started moving downwards due to the reduction in cohesion and development of pore pressure on saturation. The associated wide spread cracks developed in cultivated ground as well as houses are due to over saturation and subsequent differential settlement. The slide activities are also accentuated by the erosion of the toe of the slide by the river/nala and proximity to Main Central Thrust (MCT).

After assessing the magnitude, causes and extent of damage caused by these incidences, the remedial measure have been suggested. These include trimming/ moderation of slope by benching at less than 18° slopes; construction of retaining wall/ breast wall on fairly fresh rocks; provision of wire mesh sausages at the toe of the slide for protection against the erosion by the river/nala; sealing of ground cracks with impervious material; sealing of cracks developed in RCC houses after completion of traffic tunnel; and rehabilitation of vulnerable population.

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Geological Assessment of Slope Instability along The Atal –Tuini - Mori – Naitwar - Harkidun Communication Route in Tons Valley

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Abstract

The complex interplay of geomorphological processes is responsible for change of the landscape, which, in turn, causes varied geo-hazards to the human habitat and its developmental activities. 110 major and minor landslides along the Atal –Tuini - Mori –Naitwar - Harkidun communication route in Tons valley is an illustration to this phenomenon Where enhanced debris flow, generation of high silt content, instability of river channels and destabilisation of critical slopes are manifested to high frequency of landslides popularly known as "Storehouse of Landslides".

Several major landslide incidences in the Tons valley are recorded at or / along Myan Gad, Chibbra Nala,, Phufraila Nala , Halara Gad, Purti Nala, Giyan Gad, Syan Gad, Murar Gad, Naitwar, Jakhol, Taluka, Sirga, Dhatmir and Gangar. A major landslide got triggered due to heavy rainfall on 9th August 2003 at Naitwar Thattru market area located at 12.5 km from Mori on the right bank of Tons river, The adjacent villages including Gaichangoan, Deora, Dangangaon, Suchangaon, Halthari, Gurari and Painsar have also adversely affected. These villages are located on terraces lying at different elevations between 1500m and 2200m. But the landslide in the form of debris flow with subsequent subsidence is well pronounced at Naitwar area spreading for about one km stretch along the Mori – Harkidun communication route. The thick overburden of slope wash material is the characteristic of this slide which is coupled with toe destabilisation of the mata-stable slopes through high energy water flow of the nalas in general and Rupin nala in particular in context of Naitwar landslide. Slope failure has been documented by development of transverse cracks around Gaichangoan and Deora villages, ground sinking up to 2.0m at the crown of the slide, tilting of pine trees, tilting of cemented pillars and major cracks in residential houses and government buildings. It is evident that encroachment upon the forest land for agricultural purposes and soil erosion due to introduction of the unplanned landuse practices on hill slopes is also a causative factor for the accelerated slide movement.

The main causative factor of slides are intense heavy rain fall and cloud burst; over saturation of highly weathered material resting on precarious slope; under toe cutting by Tons river with couple of thrusting of high energy water flow of Rupin Nadi; lateral cutting by local nalas coming down the hills have led the slides and proximity to Main Central Thrust (MCT).

In these areas, the assessment data suggests that under the prevailing conditions frequency of debris slides/flow, development of badland and soil erosion may increase in future, remedial measures of landslides in the form of water current deflectors at the toe area particular at Naitwar, slope moderation, construction of retaining structures, prevention of seepage of water and development of systematic drainage system with lined drains debouching in natural streams and /or drainage lines in general are recommended.

Dam Failure—Probable Causes And Remedies

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Abstract

Ever since man started settling along the river courses, he has been maintaining an intimate relationship with the flowing water system. Over the period he has learnt and built embankments, barrages/dams to create reservoirs and control water discharges. These structures have helped mankind in his pursuit of advancement and excellence. He has used these for promotion of irrigation, supply of drinking water, mitigation of floods and droughts, generation of electricity, improvement of water navigation system, development of pisciculture, advancement of tourism etc.

The multiple benefits of these regulating structures are not without impending threats and perils. There are several problems like environmental degradation, submergence and loss of land and properties forcing rehabilitation and resettlements. In a worst scenario, dam failure may occur. It may happen due to inadequate geological/geotechnical investigations allowing erection of dam on unsound material, insufficient hydrological data, improper treatment of incompetent foundation and abutments, faulty design, use of substandard construction materials, seepage and piping, over topping of flood waters, poor maintenance and lack of preparedness and planning for combating the failure.

Citing few case studies the present paper discusses the various causes of dam failure, which, indeed is a man made disaster. It emphasizes on various preconstruction stage geological/geotechnical explorations/investigations, construction stage quality control measures and operation stage maintenance works for enhancing dam stability. The paper also makes an attempt in improving implementation of real time early warning system and damage control mechanism in the event of dam failure.

Awareness and capacity building in landslide mitigation

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Abstract

Landslides are the common problem specially in hill areas of Himalaya. The impact of landslides could be well observed by individuals, society and the surrounding physical environment. In geodynamically active Himalayan belt the landslide hazard incidents are sometimes uncertain and may trigger in many locations causing colossal loss of life and property. Though the problem of landslide controlled by the underlying geology but the external forces also play an important role as triggering factor. In North eastern region the incidents of rainfalls are more and severe than the other parts of the Indian Himalaya, therefore, the record of landslides are also more. Due to favorable conditions the forest area is also high as compare to NW Himalaya. The area left for development of a village or other developmental activities have there own limitations. In such circumstances sometimes the risk factor overlooked and dwelling developed in vulnerable areas. In any condition if landslide triggered in the vulnerable areas than the locals are either loses their life and property or forced to evacuate the place. If the landslide triggered in other places where it affect the developmental activities or road communications lead to various day to day problem to the concerns and dwellers of the areas. The state government having various programs on landslide mitigation. These programs are being implemented in different parts with the help of various organizations. It is felt during the field visit and interaction with state government officials that the awareness and capacity building is required in this direction. Programs for awareness and capacity building have been organized through National Institute of Disaster Management and Land Revenue and Disaster Management Department Govt of Sikkim by Disaster Management Faculty. In this study details of program organized and out come will be discussed.

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Snow and Ice Avalanches Hazard Zonation using GIS

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Abstract

Avalanches are one of the most destructive phenomenon of nature in snow bound regions, and therefore, Avalanche Hazard Zonation is necessary for planning future development activities. There are three main causative variables that influence the occurrence of avalanche phenomenon: the terrain characteristics, snow-pack condition and prevailing meteorological conditions. The Pirpanjals and the Great Himalayas, besides other ranges, experience heavy snow during the winter months particularly from January to March. The total snowfall is as much as 1500 cm in some years in the Western Himalayas. Storms lasting for several days bringing down at times more than 200 cm of snow in one spell lasting from 3 to 7 days are not uncommon. The problem is further accentuated when high intensities of 8 to 10 cm/hr prevail. The result is a heavy avalanche activity affecting Army posts and movements, communications, villages and winter tourism. The avalanche activity is most pronounced during Januray to March. Taking care of these reasons, 10 main avalanche sites have been demarcated along the Manali –leh highway. Virtual field has been created in GIS mode based on toposheets, imagery and other using Arc-view 3.2 & 9, Arc-GIS 9, and Erdas 8.7 softwares. Visual as well as digital interpretation of satellite images has been done to determine the avalanche sites using multi parameters such as slope, aspect, snow area etc.

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A Preliminary Survey of Landslides in Munsiyari Tehsil, Pithoragarh District, Uttarakhand State

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Abstract

Three villages, namely Laa, Jhekla and Rumidola in the Munsiyari Tehsil of Pitthoragarh District of Uttarakhand State got adversely affected by the heavy rains that triggered debris flows/landslides in these villages during early morning at about 0230 hours on 7 August 2009. The landslides took a heavy death toll of 43 lives, who were buried alive under the debris and could not escape the tragedy. Out of the 43 dead, only 26 bodies could be recovered from the landslide area. Besides this, about 200 livestocks and several houses were also lost during the event.

The paper discusses about the causes of debris flow and the level of awareness/preparedness of the affected village communities as well as the administration/government bodies against such disasters. It also highlights the lessons learnt from the immediate response, relief and rehabilitation actions undertaken after the event. The major cause for the debris flows was heavy rains that continued for a long period during the evening before the event, followed by blockade of natural drains which bursted when a cloudburst took place at night. It lead to debris flows over an area inhabited by the village people and engulfed the residents therein. Most of these buildings were Kutcha and made of stone & mud-mortar covered with slate-roof. On the response part, it has been observed that the first communication about the event was made to SHO, Police Station, Munsiyari after 6am through the event occurred at 2:30am. The police took immediate action and started recovery of buried bodies with support from local people. Later, support came from ITBP, Administration and NGOs to help victims in relief and rehabilitation.

The paper discussed the roles and responsibilities of administration, police, para-military forces, NGOs, Media and District Disaster Management Authority with reference to this event. It highlights what went right and what went wrong during this event so that the lessons learnt may be used for reducing the risks in future from such events.