CHARACTERIZATION FOR LANDSLIDE ASSESSMENT PURPOSES

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The Philippines experiences every year a wave of landslides of various forms and magnitude. These slope hazards occur in several highly urbanized areas or remote mountains that have unique geological, geomorphological, hydrological and geodynamic setting. However, despite the annual occurrence or recurrence of such hazards, and notwithstanding its negative effects to human life and its damaging consequences to major infrastructure and development, no comprehensive landslide hazard risk assessment has so far been developed and implemented.

This technical paper will attempt to identify the factors that contribute to slope failures based on the author's landslide research experience at Antipolo, Baguio, Leyte and Davao. Based on the identified factors, a slope characterization scheme will be proposed to ensure that adequate and relevant data are used in landslide risk assessment. Additionally, the various processes, and conditions that destabilize the slope/terrain will be presented including the major triggering mechanisms.

Several slope failures at Antipolo, Davao, and Leyte will be presented as Case Histories.

DEVELOPMENT OF LANDSLIDE HAZARD MAPPING IN THAILAND

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It was found that the frequency of the landslide events in Thailand is increasing sharply for the last decade starting from 1996-2006. The assumptions of the cause of increasing number of landslide for the past decade are: 1) landslide actually occur more often, 2) mismanagement of land use in the hazard areas and, 3) both reasons as indicated. Landslide hazard zoning shall be the solution in order to reduce number of losses. Various organizations have contributed their effort in making their own landslide hazard maps of Thailand. However, different landslide susceptibility factors were considered by different organizations. Factors considered are related directly to their expertise in each organization. Geotechnical engineering method was used by Geotechnical Engineering Research and Development center (GERD), Kasetsart University, however that method, even though accurate, is not fully appropriate to use in large area since details input required. Weighting factor method has proved to be suitable for large zoning area. Various factors that indicated landslide potential were considered in the analyses including the new factor, the geotechnical engineering properties of residual soil such as strength reduction, which hasn't been considered by any. In order to include this factor in the hazard mapping analysis, appropriate laboratory testing was designed to determine the properties that can indicate the landslide potential of each type of residual soil. As for rainfall factor, the rainfall accumulations of various return periods were used instead of using the average rainfall intensity or annual rainfall precipitation. GIS tool was used for map making.

EARLY WARNING OF LANDSLIDES BASED ON RAINFALL THRESHOLD VALUES

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With more frequently occurring extreme rainfall in many parts of the world, use of threshold rainfall values for establishing early warning systems for landslides are getting more and more attention. Some countries claim promising results using this concept, while a number of specialists are hesitating to the applicability.

The presentation will focus on the following subjects:

- A review of the gathered experience and approaches for the application of the concept in some selected countries in Europe, Latin America and Asia.

- An analysis of the complexity of the concept and a proposal for which conditions such systems might be most appropriate to utilize.

The presentation will also show examples of monitoring equipment, data acquisition, and communication tools that are being used.

COMMUNITY-BASED DISASTER RISK MANAGEMENT APPROACH

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Activities, projects, and programs to reduce disaster risks are primarily designed by people living in high risk localities and are based on their urgent needs and capacities. A Community-based Disaster Risk Management (CBDM) approach has the features and elements such as participatory in the process and content, responsive, integrated, proactive, comprehensive, multi-sectoral, and multi-disciplinary, and empowering and developmental. Essential components of a CBDM process are community profiling and initiating process, community risk assessment, community-managed implementation, monitoring and evaluation, initial community disaster management, and strengthening of CBDM organization.

HISTORY OF GROUND MOVEMENT OF THE PROJECT SITE

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The Baguio Pine Garden Villas is a residential development project located in Barangay Asin, Baguio City. A geotechnical investigation for the project which was undertaken in October 1997 revealed that the subsurface conditions of the site consisted primarily of stiff clayey silts and lean clays underlain by limestone. Shortly after construction began in 1997, significant ground movements were noticed in a slope in the northeastern corner of the site. An ocular inspection of the site was performed in October 27, 1998, and a subsequently engineering study was undertaken in January 1999 to investigate the cause of failure and formulate appropriate mitigating measures for stabilizing the slope.

This discussion narrates the occurrence of ground movements in the study area since 1998 to the present, and the subsequent engineering intervention measures undertaken to arrest these movements. It was noted that ground movements were greatest during period of high precipitation indicating that such movements may be rainfall induced. It was also noted that exposure of the underlying soils to elements due to excavation related to the construction of new residential building may have magnified water absorption and further contributed to the instability of the slope.

SLOPE FAILURE MONITORING AND INTERVENTION: THE NEED FOR A DETAILED TOPOGRAPHIC MAP

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The slope of an area affects surface drainage and is an important factor in the stability of the land surface. Topographic maps provide the basic information about the slope—its steepness, slope aspect, slope gradient, which are crucial in terrain stability assessment, in mapping debris flow, or in analyzing avalanche risk. Detailed slope information is essential for monitoring and coming up with reliable slope characterization; this is crucial to assist in determining how a slope failed and what caused the failure. On slope failure prediction, detailed slope information is also necessary in analyzing risk and determining where failure could occur.

As the demonstration area of this project is small (~8,000 sq. meter), locational accuracy is important. Deployment of slope monitoring instruments is dependent on the characterization of the slope in this area. A topographic map of 1-meter interval is created through field measurement to depict the demonstration area; while a digital elevation model and image from ASTER (15m resolution) is used to show the general terrain and landscape of the vicinity.

Hence, in this case, remote sensing images are used to give information on the morphology, land cover /land use, and some geological details. On the other hand, as more information are gathered, geographic information system (GIS) analysis is going to be used in integrating the various information and in making the first steps at analyzing landslide risk in the vicinity.

GEOLOGY AND MECHANISM OF THE LANDSLIDE AT THE PROJECT SITE

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Landslide movement on a steep slope adjacent to the Baguio Pine Garden Villas (BGV) in Baguio City has been active since October 1998. Timing of movements coincided with the rainy months of Baguio City. The Late Miocene Mirador Limestone underlies the problematic slope. It is a karstic-type coralline limestone, thinly bedded and gently dipping to the southwest. Dominant structures consist of NNW and EW joint systems, both of which are steeply dipping.

Residual soil derived from the limestone is medium plastic, with a liquid limit of 60-75%, plastic limit of 37-43% and plasticity index of 23-32%. Limited exposures on the slope show a limestone bedrock mantled by angular rubbles from the bedrock and thick soil. Geomorphological analysis and stratigraphy from borehole data revealed that the slope is largely formed by interbeds of silt and limestone rubbles. It is interpreted that the lower part of the slope, at least, forms part an **alluvial fan deposit** built up by rock falls and stream deposition. On the surface of the slope are fill materials derived from the construction of the Naguilian Road and more recently, from excavations within the BVG. Suspected slip surface either lies at the interface of fill and the original slope or deeper within the layered alluvial fan.

SLOPE STABILITY ANALYSIS OF THE SLOPE AT THE PROJECT SITE

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The Baguio Pine Garden Villas is a residential development project located in Barangay Asin, Baguio City. Shortly after construction began in 1997, significant ground movements were noticed in a slope in the northeastern corner of the site. An ocular inspection of the site was performed in October 27, 1998, and a subsequently engineering study was undertaken in January 1999 to investigate the cause of failure and formulate appropriate mitigating measures for stabilizing the slope. In this study, the stability of the slope was analyzed using limit equilibrium methods based on a total stress formulation, and assuming a circular slip surface. Undrained shear strengths used in the analyses were obtained through correlations with results of SPT blow counts, and standard laboratory classification tests. Results of these analysis indicated factors of safety well above 1.5 indicating leading to the conclusion that the failure was not deep seated.

In the current study, a series of stability analyses are performed to evaluate the stability of the affected slope. Limit equilibrium analyses were performed using RocScience SLIDE 5.0. Analyses performed assuming undrained shear strengths and a circular slip surface all yielded factors of safety above 2.5. Analyses performed assuming undrained shear strengths and a non-circular slip surface gave factors of safety that were slightly less than in which a circular failure surface was assumed, albeit the factors of safety were still above 2.5. Analyses performed assuming an effective stress formulation with seepage occurring within ML layer yielded factors of safety that were significantly lower than those obtained using undrained shear strengths. Analyses based on a circular slip surface yielded factors of safety between 1.13 to 1.43, while analyses based on a non-circular slip surface yielded factors of 1.0 and 1.3. The results clearly indicate the effect ground seepage has on lowering the factor of safety, as well as the likelihood that the slip surface is non-circular. The above mentioned results are further by finite element analysis in which the stress reduction factors similar to the factors of safety obtained using limit equilibrium methods were obtained. The finite element studies also indicate that the sliding mechanism is characterized by planar sliding along the interface between the ML layer and the underlying limestone formation.

MACCAFERRI SOLUTIONS FOR LANDSLIDE MITIGATIONS

Debi Ghoshal
Philippine Gabions, Inc.

Maccaferri is a world leader in engineered environmental solutions: our expertise includes solutions in retaining wall systems (gabion, geogrid), reinforcement of steep slopes, embankments, drainage systems, rockfall protection, soil erosion protection and coastal protections.

Part of a wordwide industrial group, Macaferri has more than 125 years experience in soil stabilization. Traditionally known for its double twist Gabions and Reno mattresses, Maccaferri has extended its product range significantly over the last decade, enabling us to offer an unrivalled range of wire, geosynthetic and natural fiber products to the construction industry.

Maccaferri's exclusive Philippine distributor, Philippine Gabions, Inc. assures that Philippine customers are given the full range of support services such as stocking of fast moving items, design assistance, installation training and supervision.

Landslide can be a result of various factors, surface and subsurface erosion, phreatic pressure, loose boulders, presence of joints and many more.

Maccaferri has developed customized solution for most of these problems, below are listed some of our solutions:

- For simple erosion protection, Maccaferri can provide BioMac™ biodegradable erosion control mats: MacMat™ 3D permanent erosion control mats for steeper slopes MacMat™ combined with Maccaferri rockfall netting will provide better results for problematic areas.
- Retaining walls, such as gravity type gabion retaining walls, reinforced soil walls, segmental retaining walls and reinforced earth retaining walls with vertical facings.
- For rock fall related problems Maccaferri Mac.R.O.™ systems can provide a varied range of solutions based on the topography site situation and the rock morphology. Standard with standard rock fall netting up to HEA panels and CTR barriers. Macaferri provides the widest range of solutions for all possible problems related to this sector.
- For fissured rock strata Maccaferri can provide specialized Wirand fibers for fiber reinforced concrete applications.

Today the Maccaferri Industrial Group can be considered as the most comprehensive solution provider for this sector. With its vast experience and knowledge bank, in house proprietary design software and various international accreditations they are your best partner to provide the most economical and long lasting for your landslide problems.

NEW TECHNOLOGY FOR STRAIN MEASUREMENTS IN SOIL AND THE SURVEY OF REINFORCED EARTH CONSTRUCTIONS*

L. Briancon[1], A. Nancey[1], F. Caguel[2], and P. Villard[3]
[1]*BIDIM Geosynthetics S.A*
[2] *LRPC Nancy*
[3] *Lirigm*

The survey of civil engineering works and reinforced earth structures is more and more necessary either to detect the first sign of degradation before failure or to provide the designer/owners information on the behaviour of their structures. In the area of geosynthetics, such surveys have been requested mainly in the case of soil subsidence risk, relating to the quicker construction techniques available using appropriate geosynthetics. Until recently, only systems that should be installed by hand were available whatever the accuracy of the measurement. This made the survey of large areas difficult

In this context, the “Geodetect” program was launched to develop a warning system using the advantages of optical technology inserted within geosynthetic. The results of the development comprises a reinforcing geosynthetic equipped with optical fibres, which offers an accurate measurement system, available for very larges areas, which is easy to install and includes an analysis device and warning system, which may be adapted to the clients needs.

This paper introduces the different steps of the validation including laboratory testing for fine tuning of the system, an experiment in the LRPC Nancy to show the resistance against damage during installation and the behaviour of the geodetect above the cavity.

***** presented by **Dr. Kean Loke** of TenCate Geosynthetics Asia

BAUER: LEADERS IN ADVANCED FOUNDATION TECHNOLOGY

Adrian A. Madrazo
BAUER Foundations Philippines, Inc., Quezon City

BAUER FOUNDATIONS PHILIPPINES, INC. (BFPI) is a subsidiary of BAUER Spezialtiefbau, a German based company, which have been active in Southeast Asia for the past 30 years. BFPI was established in the Philippines in 1995.

Since then, BFPI has executed bored piling of diameter sizes ranging from 800mm to 3000mm forindustrial and commercial complexes, for elevated highways, MRT and LRT, as well as for groundimprovements using stone columns and soil cement columns. The company's clientele includes local companies such as SM Prime Holdings, Inc. Robinson's Land Corp., EEI Corp., and Filinvest, as well as First Phil. Balfour Beatty, Hazama Corporation, Sumitomo, Luzon Hydro Corp. and other international construction companies active in the Philippines. BFPI's major works are divided into five categories, namely: 1) Piling (bored piles up to 3.0m, micropiles, minipiles, piles under restricted headroom, continuous flight auger bored piles, post-grouting for all piles), 2) Slope Stabilization (soil nails of temporary or permanent type, soil anchor systems, shotcrete, soil stabilization thru Soil Cement Columns, Soil Mixing and other techniques), 3) Retaining walls (diaphragm wall, secant pile wall, contiguous bored pile wall, sheet pile wall, H-pile wall, soil nailing system, Gunite walls, trench cutting technique, mixed-inplace retaining wall), 4) Soil improvement (stone columns using dry or wet method, soil-cement columns, Vibro-compaction, dynamic compaction, permeation grouting, vertical drains), low pressure grouting, jet grouting and all kind of soil treatments and 5) Cut-off systems (slurry trench walls, horizontal grout blankets, mixed-in-place cut-off wall).

It is BFPI's task to provide a high quality service at market cost. In fact, BFPI has shown in the region that wherever high performances were required to complete large volume of work, BFPI was able to execute such projects on time and at very competitive rates. This is possible due to the active linkage of cooperation (networking) of other BAUER subsidiaries in the Southeast Asia.

With the company's vast experience in delivering services in the Southeast Asia and in the Philippines during the last 30 years, BAUER continues to prove itself as one of the leaders in advanced foundation technology.

LANDSLIDE INVESTIGATIONS AND MITIGATION MEASURES WITH EXAMPLES FROM THE HIMALAYAS

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Oslo, Norway

Landslides and other mass movements are serious geo-environmental hazards in the Himalayas. Massive landslides killing thousands of people with catastrophic damages have occurred in the Himalayas of India, Nepal and Bhutan. The presentation will give an overview of some of the hazards and the investigations carried out on recent landslides in the Himalayas 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. The presentation will also illustrate some of the inexpensive mitigation measures that have been implemented to control the behaviour of landslides

PROBLEMS ASSOCIATED WITH LAND USE PLANNING AND LANDSLIDE RISK MITIGATION

N.M.S.I. Arambepola
Asian Disaster Preparedness Center (ADPC) Thailand

Any type of interventions related to disaster risk management should sensibly evolve from the community perception and acceptance, economic viability, social acceptance, legal provisions for implementation and prevailing hazard context. They are also the products of traditional coping up mechanisms adopted by the affected, results of a human reaction to the consequences evolved from that history and the reflection of new perceptions based on the predictions using the products of advancement of science & technology. However in order to cope up with present development trends for any hazardous situation it is advisable to find long-lasting solutions to the problems.

During the past history of disaster management, various policies and practices stem from an era of **hazard control** in which the emphasis was on the physical control of hazard generating factors or triggering factors through structural interventions with huge investments. During this period - and again extending to our present day - these structures had other purposes: to provide irrigation waters, bulk drinking water supply and/or hydro-electrical power generation, road safety etc. However landslide protection measures are generally standalone measures and did not find the same popularity as in the case of flood or other hazard prevention measures since repayment for such investment in large scale standalone protection measures has become a problem.

Therefore in landslide risk management practice **non-structural measures** of **risk management** are getting favoured increasingly. The interventions such as land use plan, the planned retreat of those in danger to safe refuges, the use of property insurance, prediction and early warning systems coming in to effect as popular measures of landslide risk management. In landslide prone urban areas which are comparatively smaller in size, rather than land use planning, resettlement has become a popular solution by many authorities. This result in abandoning the land affected by landslide or with high risk and it is subjected to high environment degradation process eventually. The reluctance of authorities and owners to invest money in such abandoned land associated with landslide risk has created a new set of problems. The owners of such land after getting alternative land tend to occupy both lands and recurring events become a common feature. The other is the loss of productive land in the process especially in urban areas where land is a resource in high demand and hence this practice can not be continued in future.

Many countries in Asia are at an early stage of urbanisation and urban growth is visible in mountain slopes prone to landslides. Yet many, if not most, predominantly mountainous areas of such countries are burdened with rising populations and thus rising expectations for housing and recreational facilities, infrastructure facilities, lifelines etc. Unless these settlement trends are carefully captured and land use is properly managed the development programs associated with urban settlements, road and rail transportation

systems, tourism infrastructure, the industrial growth etc will all may aggravate the landslide problem. As the destabilized material is transported in to lower areas natural land drainage can get disturbed over large areas and increasing flooding will result.

Therefore, the authorities have to think about new land use policy environment in which more emphasis have to be given to both local level and regional level physical planning practices and mainstreaming risk management interventions in Urban Planning. Local authorities will have a bigger role in controlling the unfavourable practices at local level whereas the service agencies need to change the current approach to integrate landslide risk management measures in development practice. It is also need to have provisions for budgeting in large scale investment projects to rehabilitate the areas abandoned due to landslide risk. Other needs are public awareness creation, conduct of research for innovative and cost effective risk management practices, availability of technical information on landslide hazard in public domain so that it can be used in design of projects as well as to introduce ways to improve the local level early warning mechanisms.

NUMERICAL TECHNIQUES FOR ANALYSIS OF SLOPE STABILITY

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Oslo Norway

There have been significant developments over recent years in the methods of analysing the stability of rock and soil slopes. However, traditional methods such as the limit equilibrium methods still dominate in slope engineering. For soil slopes this method requires information about the strength of the soil, but does not require information about its stress-strain behaviour. For the case of rock slopes the limit equilibrium method only examines the incipience of motion of each rock block and does not consider the subsequent behaviour of the whole system of blocks and the movement of the slope. Therefore, the limit equilibrium techniques are used in conjunction with numerical modelling techniques that estimate the mass deformations and movements.

The most commonly applied numerical techniques are the continuum methods, discontinuum methods and the hybrid continuum/discontinuum methods. The choice between these methods depends upon the problem scale and the fracture system geometry. In hard jointed rock masses, the stability of a rock slope is usually governed by the characteristics of joint behaviour rather than the physical properties of the rock mass itself. In weak and homogenous rock masses, the physical properties of the intact rock are important for analysing the deformations and stability. In the case of a progressive failure of a jointed rock mass, the principles of fracture mechanics have to be considered and the properties of both the intact rock and the fractures are important.

The constitutive models for both intact rocks and rock fractures play important roles in the successful application of any numerical analysis technique. These models, which are formulated using both theoretical and empirical approaches, are briefly described in the presentation. Some of the commonly used numerical methods for slope analyses are presented together with a discussion on their application and limitation.

BIO-VETIVER GRASS TECHNOLOGY

Samuel E. Sapuay and Grace P. Sapuay
Quali-Infra Construction Corporation

Vetiveria zizanioides or vetiver grass is a species of coarse perennial grass belonging to the family *Andropogoneae*. It is the only grass in this group that has proven to be ideal for soil moisture and soil conservation. Its vigorous, strong, deep, and massive root systems penetrate into the soil to a depth of 3-5 meters (depending on soil conditions) into the ground. With these attributes, vetiver grass offers better shear strength increase per unit fiber concentration (i.e. 6-10 kPa per kg of root per m of soil) compared to 3.2 ~ 3.7 kPa per kg of root/m of soil for tree roots. The fact that vetiver can grow vertically on steep slopes (more than 150% or 62 degrees angle), grow faster, and impart more reinforcement to the soil makes it a better candidate to consider for slope stabilization than other plants. Its 'innate' strength and vigour enables it to penetrate through difficult soils, hard pan, or rocky layers with weak spots. Vetiver roots basically behave like 'living' soil nails or dowels of 2-3 m depth commonly used in 'hard approach' slope stabilization work.

Scientific studies funded by World Bank have established the structural and shear strength of vetiver roots, which is in the order of 75 MPa (or approximately one third of that of mild steel). This gave engineers more confidence in specifying vetiver grass for steep slope stabilization and for protection of infrastructure from damage due to soil erosion. It grows upright and with its stiff stems, it is able to form a dense hedge in 3 - 4 months and thus, capable of slowing down rainfall runoff; distribute it uniformly, filter it, and trap transported or eroded sediments at the hedge face.

In terms of cost, our contracting experiences indicate a minimum of 80% savings as compared to traditional civil engineering structures on slope stabilization. Since it is a green technology, it is resource-conservative and yields positive impact to the environment. With all these advantages, using vetiver grass as slope and erosion measure is highly favorable and recommendable to a number of field applications.

PERMANENT SCATTERER INSAR (PSINSAR) FOR LANDSLIDE DETECTION AND MONITORING IN THE PHILIPPINES

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PSInSAR is a processing technique used in radar interferometry to measure mm-scale displacements of individual features on the ground using multiple acquisitions of radar images collected over a target area by a SAR satellite. It is an advancement of the conventional Interferometric Synthethic Aperture Radar (InSAR) method, which measures the change in the distance from the satellite to the ground by determining the phase difference in the radar wavelength between different satellite passes. In conventional InSAR, sources of errors associated with atmospheric effects, topography, and changes in dielectric properties may decrease the resolution of deformation measurements. These errors are minimized in PSInSAR by identifying permanent scatterers, such as buildings and rock outcrops, which are radar bright and radar-phase stable points. Permanent scatterers that persist in multiple SAR acquisitions are used to improve the signal to noise ratio by separating a modeled deformation rate from atmospheric and elevation error components in the measured range change. By removing the errors from the signal of the permanent scatterers, spatial and temporal sampling resolution is improved and yield more precise values. The principle behind PSInSAR makes it an ideal technique to measure ground motion in areas where the conventional InSAR method may fail. This paper discusses the applications of the PSInSAR method for landslide detection and monitoring in the Philippines.

CHARACTERIZATION OF EARTHQUAKE-INDUCED LANDSLIDES

Arturo S. Daag
Philippine Institute of Volcanology and Seismology (PHIVOLCS)

The Philippines is a tectonically-active region where large-magnitude earthquakes frequently occur. PHIVOLCS is a government agency mandated to do assessments on earthquake-related hazards. And one of these hazards is landslides that can be triggered by large magnitude earthquake.

Regional-scale mapping areas prone to earthquake-induced landslides are assessed using GIS by two general methods: i.e., 1) semi-quantitative thematic overlaying techniques using weight index and decision support system, and 2) deterministic landslide models. Thematic overlaying techniques are semi-quantitative assessment of landslide using several relevant parameters. Each parameter are rated according their contribution to landslides. And the results then calibrated to known historical landslides.

The deterministic landslide modeling is done using the following procedures. These are: a) mapping of active fault lines or potential earthquake generators by geological methods, b) estimating potential earthquake magnitude using empirical equation from Wells and Coppersmith, c) calculating peak ground acceleration (PGA) based on soil stiffness and distance from the epicenter using Fukushima and Tanaka attenuation equation, d) estimating strength of slope based on Factor of Safety (FoS), e) calculating the critical acceleration of slope based on Newmark's method, and d) estimating the probability of failure by correlating PGA and critical acceleration of slope. These procedures require geological, seismological and engineering geological parameters in order to carry out the assessments on earthquake-induced landslides.

Thematic overlay methods are generally subjective and the success of the method will depend on the expert judgment. On the other hand, the deterministic models need more engineering laboratory data and there is a tendency to extrapolate the data, but the result should be better compared to thematic overlay.

COMMUNITY-BASED DISASTER REHABILITATION MEASURES: GENERAL NAKAR, QUEZON, PHILIPPINES

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The Philippine's geologic setting makes it highly susceptible to a number of natural hazards such as typhoons, landslides, and flooding. Most coastal, floodplain and upland areas experience disasters of varying degree because of these hazards. Recognizing the fact that hazards are natural phenomena inherent to a place, it is therefore imperative that communities must be informed properly to make them understand first, then act accordingly to cope when disaster strikes. The following projects demonstrate that appropriate education can empower communities to come up with effective strategies in addressing damages incurred from natural disasters and implement them efficiently given valuable human resources albeit very limited financial means.

1) KATUBIG Project – Emergency Relief Assistance for Community Potable Water System of General Nakar, Quezon

Massive landslides and catastrophic floods devastated the municipalities of General Nakar, Infanta and Real in the province of Quezon last Nov 2004. The worst hit in terms of environmental destruction and damages to properties was General Nakar. Almost all infrastructures such as roads, bridges, irrigation and potable water systems were totally destroyed. Most farmlands were totally washed out and buried under at least a meter thick infertile flood deposits. As the bridge connecting the town to the rest of the country was only temporarily restored more than a month after the event, General Nakar was the last town to administer relief operations while other municipalities were starting to put in place their rehabilitation plans. The KATUBIG Project was then conceptualized as a form of both relief and rehabilitation measures. Maximizing financial resources received from an international funding agency (Terre des Hommes), the communities, local government units, NGOs/POs and technical volunteers from academe implemented an intensive community-driven municipality-wide potable water project where each entity provided its own counterpart in the form of labor, mobilization, participation and expertise. All participants acknowledged that in order for the project to be sustainable, appropriate IEC campaign should be done simultaneously. This will ensure that all potable water systems will be put up, used, managed and maintained properly. Further, technical and scientific knowledge gained from this endeavour will help them make more informed decisions in managing their natural resources in the future. Within 5 months, a total of 70 hand pumps and 43 spring development systems were installed all over 19 barangays which cover an area of 134,930 hectares of rugged terrain.

2) ARBZ Project – Agos River Buffer Zone Establishment

As a result of the previous disaster, General Nakar's numerous rivers and rugged terrain remain unstable. Communities, specifically along the banks of Agos River, continue to

experience regular floods, erosion, excessive sediment deposition and landslides. Further, relief operations left the local government financially incapacitated to rehabilitate these areas. The communities refused to be complacent and wanted to do something. Armed with the correct scientific information regarding their environment, various sectors, once again, came together to launch another intensive community-driven endeavour. Hence, ARBZ was launched soon after the KATUBIG Project. It is a community-based, integrated and multi-sectoral undertaking which seeks to re-establish the rivers' riparian buffer zone in order to protect communities from flooding, restore ecological balance and promote sustainable community livelihood activities. It also aims to facilitate people's understanding on geohazards and practical mitigation measures they can do without relying on unclear government flood protection measures. Capacity building goals are anchored on providing appropriate knowledge and skills in efficient plant propagation buffer zone establishment and management, livelihood development, and institution of disaster awareness and prevention in the barangay and municipal development plans. The World Bank awarded ARBZ with a PhP1M grant during Panibagong Paraan 2006 to fund the pilot implementation. To date, the pilot site Barangay Pesa, has re-established its buffer zone; the remaining 10 riverside communities are preparing to implement; livelihood activities such as coconet and vetiver production and organic agriculture are in place; barangay and municipal ordinances on buffer zone protection and management are being implemented, curriculum integration of scientific knowledge used in the project are being taught in various subjects such as Science, History, social Studies and Values Education.

Learning from General Nakar's resilient and empowered communities, the key elements to a successful community–based rehabilitation strategies are 1) Appropriate education which will create empowered communities and help them make informed decisions to maximize their limited resources; 2) Collaboration between LGU, communities and technical volunteers, each contributing their various capacities; and 3) Sustainability to ensure long term benefits.