National Building Research Organisation
Ministry of Public Administration & Disaster Management

NEWSLETTER

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ENVISIONING RESILIENCE

IN THIS ISSUE

Dear Readers...

This newsletter unfolds news articles mainly focused on Envisioning Resilience.

As many are settling into accepting extreme weather events and chronic stresses as the new normal, it has become clear that events we expected to occur in the 'far future' have arrived and are bound to intensify. If we couple these developments with other accelerated changes of our era – rapid population growth, urbanization and migration, along with surging connectivity and digitization, and severe degradation of our environment, we could see reason to be alarmed.

The resilience approach offers valuable insights on how to proceed and enable in the short term the path for long-term climate planning under high uncertainty. Envisioning positive futures, anticipating changes, and strengthening adaptive capacities of our systems is key to transformational change.

Hence we are happy to invite you to read the newsletter and provide your valuable feedback to incorporate in our future activities.

Best wishes,
Eng. (Dr) Asiri Karunawardena.
Director General
National Building Research Organisation.

In this issue

Editorial Committee.

Mr. K.C.Sugathapala, Director, Human Settlements Planning and Training Division.
Mr. Clarence Perera, Consultant, R&D Programme. NBRO.
Mr. Jude Prasanna, Scientist, Human Settlements Planning and Training Division.
Mr. Chinthaka Rathnasiri, Senior Scientist, Human Settlements Planning and Training Division.
Ms.Deemathi Perera, Scientist, Human Settlements Planning and Training Division.

Cover page design - Mr.Nishan Gunathilaka

Learnings from Community Based Landslide Risk Reduction Initiatives in Badulla District

Jude Prasanna, Scientist, Human Settlements Planning and Training Division
Wasantha Pradeep, Scientist, Human Settlements Planning and Training Division

Since local people are the ones affected when disasters occur, they become the first responders at the household and at the community level. Capacity of the local people should be built so that they are be able to assess the risk beforehand and identify, prioritise plan and implement risk reduction measures at community level. Human Settlements Planning and Training Division of the National Building Research Organisation (NBRO) implement landslide risk profile development project since 2016. This project was initiated to meet the outcome-1: National and sub-national level agencies are capable of assessing disaster risk and making decisions for short, medium and long term disaster management of the Sri Lanka Comprehensive Disaster Management Programme (SLCDMP) 2014-2018. Adhere to this outcome, risk profiles have been developed to enhance the capacity of national and sub-national level agencies in assessing the disaster risk and formulate short, medium and long term disaster risk reduction decisions. In Badulla District spatial database on buildings that are located within landslide hazard zones (i.e. 1. landslides are most likely to occur, 2. landslides are to be expected, 3. landslides have been occurred in past, and 4. subsidence & rock fall) was established. As the next step of the landslide risk profile development, requirement of community awareness on landslide risk reduction, community landslide hazard mapping and participatory vulnerability & capacity assessment weve recognised. Aim of this initiative is to educate the vulnerable communities on landslide susceptibility and embed good slope management practices to protect against landslide risk. Community awareness, community landslide hazard mapping and participatory vulnerability & capacity assessment undertaken among ninety four Grama Niladari divisions in Badulla district. Community disaster management cells also were established with the guidance and networking of the Disaster Management Centre (DMC) to take over the responsibility of early warning, preparedness, response and identification of community landslide mitigation measures.

Step 01: Community awareness on landslide risk reduction

An important aspect of any disaster preparedness programme is to anticipate the requirements for

Delivering community awareness

disaster related public awareness, education and training. Communities need to understand the landslide susceptibility they face. Awareness was carried out among ninety four Grama Niladari divisions, where awareness programmes had not been carried out before. Public awareness and public education for landslide risk reduction intend to empower vulnerable communities to participate in reduction of future landslide threats. Awareness on landslide risk reduction expects substantial improvements in public response to landslide hazard. Community awareness building programmes on landslide risk reduction covers following components;

- Introduction to the subject of landslides
- Causative factors of landslides
- Role of community in landslide risk reduction
- Structural and non-structural community interventions for landslide risk reduction.
- Possible early warning options available with the community to deliver early warning message.

Step 02: Community-based mapping for landslide hazard assessment

Community landslide hazard mapping

Community based mapping is the central element of Community Based Disaster Risk Reduction (CBDRR) approach. Community members are fully engaged in landslide hazard mapping process, not just as providers of information, but as active participants in the development of landslide hazard maps. Community landslide hazard mapping allows the local community to determine localized slope stability features, identify zones of past landslides, and potential future landslide hazard and identify the dominant causes of the landslide hazard in different zones of the slope. Unsafe zones, areas safe from landslide hazard and secure evacuation routes also are identified in community landslide hazard mapping.

Step 03: Participatory Vulnerability and Capacity Assessments (PVCA)

Member of the community presents the PVCA assessment

Participatory Vulnerability and Capacity Assessment (PVCA) is a critical step in raising awareness of the hazards, vulnerabilities and capacities of the community, and engaging the community in identifying its own disaster risk reduction activities. PVCA for landslide risk reduction enables people to assess the elements at risk, possible causalities, reasons for causalities, and capacity of the community with regard to landslide risk reduction. Possible landslide risk reduction measures are also identified by the community through the participatory approach.

Step 04: Instruction on rainfall measurement for monsoon preparedness

Rainfall is the main landslide triggering factor in hilly areas of Sri Lanka. Under this initiative, manual rain gauges are distributed among selected community members to cover the entire village for rainfall measurement. Training is also provided; rain fall reading with gauges marked with threshold levels, dissemination of warning messages and preparedness on possible landslide threat during rainy days. Village disaster management cells were established in ninety

Instruction on rainfall measurement and preparedness for landslide

four Grama Niladari divisions and these cells will be responsible for; patrolling/vigilance, preparedness, response, take actions to prevent inappropriate land use practices, identify safe places for evacuation and establish a simple communication system to disseminate warning messages among the villagers.

Lessons learned

Lessons drawn from practice are always considered to improve performance. Following are the learning from community based landslide risk reduction initiatives undertaken;

Enhanced knowledge on role of community in landslide risk reduction

- Community members appreciate the initiative as it is the first time they had the opportunity to listen and understand the role of community in landside risk reduction.
- Awareness of the community increased organisation capacity of community members to respond in the event of landslide occurrence.
- Communities wanted to empower themselves with real time landslide early warning, so that they themselves can take decisions on self-evacuation.

Community based landslide risk reduction approach is essential

- Community members are especially encouraged by the participatory approach in which they themselves propose solutions to overcome landslide threat.
- PVCA reveals inadequate drainage system to manage surface water is the main reason for landslide vulnerability in most of the villages. It reiterates the need for community managed landslide risk reduction measures, particularly on surface water management.
- Most of the communities do not organize themselves to manage landslide risk within their entity and looking for support from public agencies. Thus, culture of gathering communities to work together on community managed landslide risk reduction measures to be promoted.

- Discontinuity between the completion of the Participatory Vulnerability and Capacity Assessment (PVCA) and the implementation of community lead landslide risk reduction measures appears to have been a key challenge.

Need to overcome the conflict between community and decision makers

- Due to several delegated agencies operate at local level, approval from these agencies is necessary in the event of decision making on local level disaster risk reduction initiatives. This lead to conflict between community and the authorities as a result of benefit to community deviate by the authorities.
- Authorities engage in road construction not consider landslide vulnerability prevail in the areas.

Sketch illustrates by a villager shows how a road development project lead to activities of landslide. It was revealed by the villagers that the settlement was safe prior to road construction. Due to road construction, surrounding environment is filled with soil and blocked the drainage system as well. In rainy days mud flow towards houses, which are located on slope. It is the result of inappropriate decision making by the authorities.

- Community revealed many resettlement sites are in unsafe condition. Although number of agencies engage in resettlement projects none of the agencies take measures to mitigate slopes at the resettlement locations.

Importance of Geotechnical Assessment During High Rise Construction in Sri Lanka

Winson Ganatheepan, Scientist, Human Settlements Planning and Training Division

Geotechnical investigation carried out for a high-rise development could be used as a tool to communicate the site conditions, design requirements and construction recommendations. The importance of adequate site investigation and preparation of comprehensive geotechnical report cannot be over emphasized. Reliability of the information contained in a geotechnical report has a strong influence on the design, construction, project cost, safety and resolution of contractual disputes and hence, the report must be clear, concise and accurate. Inadequate geotechnical investigations are many times source of costly, over designed foundations, project delays, disputes, claims, and project cost overruns. Lack of adequate information from the Geotechnical Report may sometimes lead to deeper excavation for founding depths and hence to uneconomical design of foundation.

While architects and structural engineers are able to visually document the success of their planning efforts on each high-rise project, successful geotechnical services remain hidden underground. They are only visible or experienced when errors were made in the ground/subsoil assessment or in case of poor planning, resulting in building damage, construction delays and additional costs. Although the construction costs for the excavation pits and foundations of high-rises generally account for less than 10 per cent of the total construction costs, the ground and the subsoil are major risk factors in high-rise construction. Hence, the geotechnical engineer is faced with special challenges and responsibilities in planning and monitoring the construction of high-rises. The added value, which results from professional geotechnical services for the project and the client body, can be considerable and has a decisive influence of the overall success of the project.

Design which is made considering the recommendations of a proper geotechnical investigation would ensure the safety and integrity of the structure. This would ultimately minimize the impacts caused to adjacent structures by the proposed development. Urban Development Authority (UDA) which is a main regulatory body of development in Sri Lanka, is preparing regulations necessary for controlling and regulating of development but it is unclear whether these development regulations take into consideration the importance of geotechnical parameters. Country's existing building approval process does not have any step to examine geotechnical aspects of a project unless UDA or any other project approving agency refers the developer to obtain a clearance from NBRO. This has given professionals a freehand ability to design the structures. At some instances approvals have been given even beyond the existing height limitation, without considering the

geotechnical aspects as well as the views of the public. In several instances, this has led to inhabitants in such areas to seek legal assistance through court to halt the project, ultimately causing delays in the project implementation and preventing the investors from earning the return on investment on time.

Further, there is no legally mandatory requirement in Sri Lanka to conduct a proper geotechnical investigation prior to any development. This become as another escapable factor for the professionals to evade from their responsibility. This provides a chance for evasion. Sri Lanka so far had lucky escapes in relation to devastative building disasters. During the past couple of years the country experienced a few minor building collapses which occurred due to poor construction practices associated with loopholes in the approval process. These incidents show that Sri Lanka cannot have these lucky escapes for long.

Therefore, it is high time Sri Lanka to re-ponder its building approval process and incorporate geotechnical aspects rather than merely focusing on planning aspects. This cannot be done only by either planners or engineers alone but require the collaborative efforts of multi-disciplinary professionals.

Importance of incorporating a geotechnical layer into landslide risk maps

Lilanka Kankanamge, Scientist Sanchitha Jayakody, Scientist Wathsala Galhena, Scientist
Geotechnical Engineering Division

Landslides, during the past few years, have become one of the recurrent incidents in Sri Lanka and the main cause for numerous deaths, damage to property, disturbance to natural environment and several other issues which drastically disturbed the socio- economic lifestyle of the people in the country. NBRO, over the years, has been playing the main role behind the landside risk reduction, identifying the landslide risks, evacuating the people, resettling and also adopting proper mitigation measures then and there. Having experienced in different landslide related issues over the years, NBRO is now in a process of upgrading and upscaling the landslide risk identification and hazard mapping programme, with the use of modern technologies and knowledge gained in collaboration with foreign expertise.

Consequently, it has been proposed to widen the risk zonation mapping, from qualitative approach to a quantitative base approach which indeed results in inputting geotechnical know-how to the risk identification process. In this regard, a training programme was held recently with the collective participation of NBRO, Norwegian Geotechnical Institute (NGI) and Asian Disaster Preparedness Centre (ADPC). It was rather a desk and field oriented programme, conducted for NBRO scientists to demonstrate how the geological, geomorphological and more importantly geotechnical parameters, which was not there formerly, could be used to streamline the process of zonation mapping and risk identification.

Sophisticated software used in the programme is capable of analyzing different situations even from vadoze zone, where negative pore water pressures dominate, to fully saturated conditions in the ground. The most pivotal aspect is the prediction of the flow path with an improved degree of accuracy, which eventually eliminates the unnecessary resettlement. Besides, it is of utmost importance to have a sound prediction of the debris flow path. Therefore, we as NBRO, believe that developing an accurate maps showing the exact vulnerable areas is a contemporary need.

Geotechnical parameters are one of the main inputs to identify the initiation of a landslide and for prediction of the debris flow path. Therefore, to run a simulation with a higher accuracy and to a higher scale of resolution, geotechnical parameters have to be inputted in a way that gives representative values otherwise it will not predict the most exact solution. Hence, this shows an urgency of determining the geotechnical properties of soil which is a necessity to forecast the landslide initiation and debris flow path.

Application of web based GIS in the development of Landslide Hazard Information System

S. Jayaprakash, Scientist, Human Settlements Planning and Training Division.

National Building Research Organisation is in the process of developing a detailed geospatial database of elements at risk in landslide prone areas of the country. Purpose of this development is to provide geospatial database system irrespective of time or location, this geospatial database will enable sharing of information & data among all the stakeholders who are directly or indirectly connected to landslide risk management in the country. In addition, this database includes the list of special investigations carried out in the landslide prone areas. At present, NBRO is collecting household information of buildings which are located in landslide risk areas in identified ten districts of Sri Lanka, which are necessary for the development of geospatial database.

Sharing information with its stakeholders is one of the main challenges that NBRO is facing. The currently used methods such as printed materials and conventional websites inherit the limitations in the accessibility to information, the volume of contents and the quality of information. To address this issue, NBRO applied upcoming Web GIS technology for sharing the geospatial information with its stakeholders.

In the NBRO application, web GIS technology is used to integrate spatial data of landslide hazard, buildings, roads, hydrology and administrative boundaries with the linkages to non-spatial data such as numbers, characters or logical type and share them through an interactive web interface. The new system will provide users a 24-hour access to the spatial information of target areas and to take decisions based on an up to date information base. Through the system, users gain access to information such as the population exposed to landslide hazard, conditions of buildings, evacuation routes, magnitude of risk, etc.

Establishment of the web-based landslide hazard information system can be achieved by following three main steps.

1. Establishment of spatial database

It is required to establish a spatial database that can provide a platform to store, query and analyze data. It should allow representing other data layers such as landslide hazard, landslide risk, transportation and hydrology networks, and administrative boundaries as the form of geometric objects such as points, lines, and polygons. Further, it should provide the facility to store three-dimensional data types such as topological, satellite images, etc. To establish and manage the geo-spatial database, it requires expert knowledge on preparation of a spatial database and fluency in geo-spatial software such as ArcGIS, QGIS, and Post GIS.

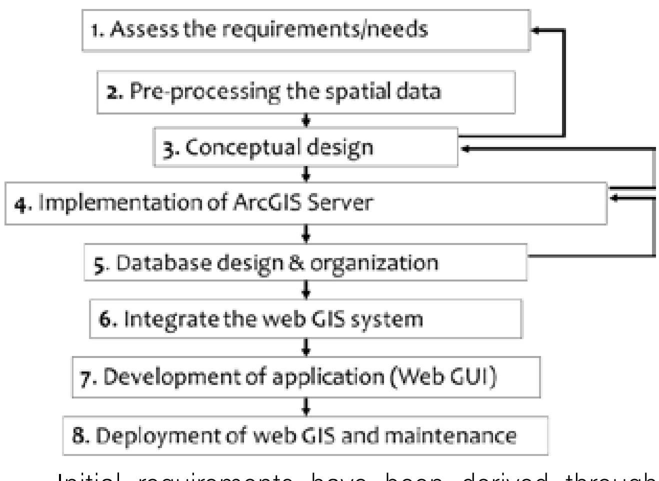
2. Establishment of server-side applications

It is required to establish a database server with required applications which can store both spatial and non-spatial data.

3. Development of web based graphical user interface

This is aimed to develop a web-based graphical user interface which users can request, view and download spatial data. Graphical user interface is designed in such a way that can be used by a person who has little or no knowledge on spatial data management.

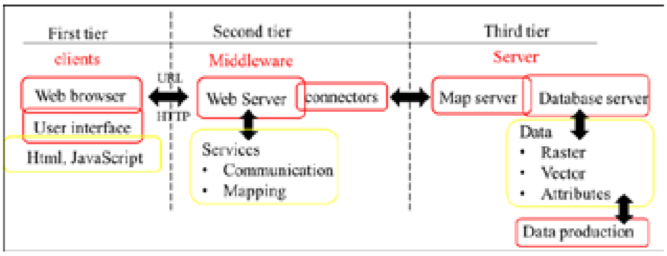
The process of establishment of this system is based on typical steps that are involved in web-based GIS development, as described below.



- Initial requirements have been derived through the discussion with potential stakeholders and the developed application gives information related to the required inbuilt functions and the spatial data layers

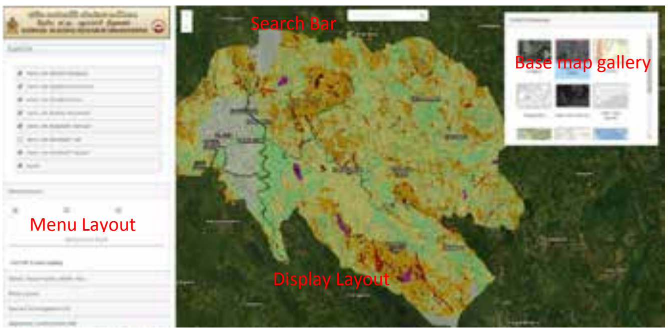
- In order to establish the spatial database for the landslide hazard information system, it is essential to pre-process the spatial layers involved in this process. It includes defining the spatial reference (geographic coordinate system) and repairing geometry to eliminate the errors in layers' geometry.

- Suitable web GIS architecture has been selected based on the consideration of data visualization, size of the database, required inbuilt functions, security and accessibility. Many of the effective web applications which are similar to this purpose have been built upon on 'three-tier architecture' as a thick client system. This system works through three main components such as client-side application access through web browsers which contains user interface populated with variety of functions and built up on HTML, CSS, JavaScript and J query scripting platforms.



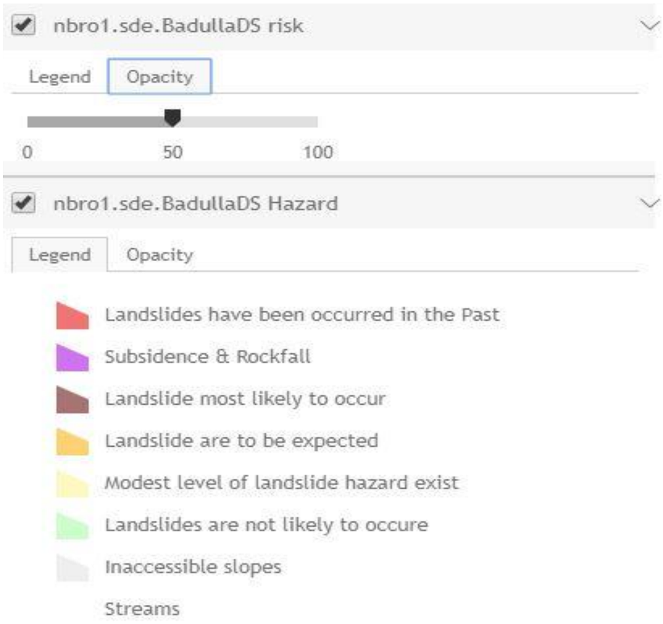
- As interpretation of spatial information depends on the visualization and user-friendly control functions, it is essential to add such modules in the graphical interface. With the support of ArcGIS API for JavaScript it is possible to create functional buttons which can fulfil the requirements that derived from users.

A web-based graphical user interface for Landslide Hazard Information System is shown by the following figure; currently this system has been established within the local network of NBRO for testing purpose. Once the system is fully completed it will be opened to the public. This interface consists of four main components. The



first component is menu layout which contains spatial layers related to landslide hazard with appropriate legends and other displaying properties. Others are functional components such as measurement and filtering options and the print layout help to export the map of the area of interest.

Layer list contains following layers: -



1. Buildings
   - Households
   - Religious
   - Commercial
   - School
2. Landslide risk layer
3. Roads at risk layer
4. Landslide hazard layer
5. Administrative boundaries
6. Special Landslide Investigation List
7. Resettlement sites

Print widget helps to export the area of interest with

Layer window

toggled features by users, and it has other options to define title, page and file format.

Search bar helps to filter the spatial data based on the different levels; Search the buildings by entering the address, Roads by categories, Hazard and risk by types. And also, it directs to the area of interest by entering the name.

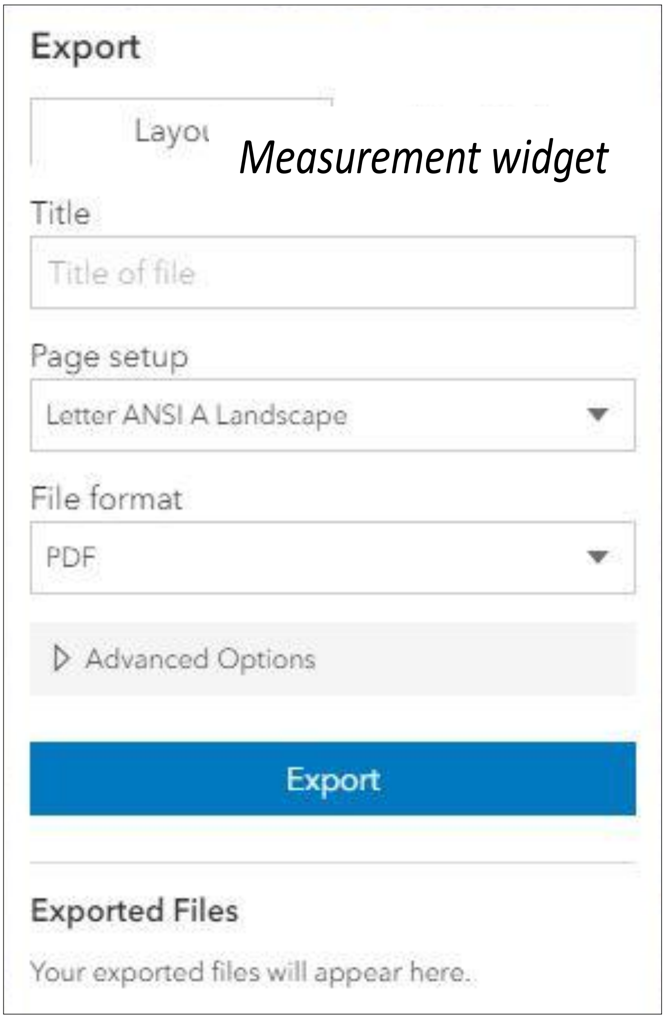
Display layout helps to visualise the spatial layers listed in the menu bar and one clicks in desired layer will pop up the information window which shows the details of the specific layer.

Measurement widget contains three features; area measurement which measures the area in free hand mode and converts into the required format, path measurement for line measures, GPS measurement for get the coordinates.

Through the base map gallery, it is possible switch to various base maps such as satellite images, open street maps, topography, terrain layers.

Landslide risk information portal can be accessed in the NBRO's web site. (nbro.gov.lk)

Measurement widget



Envisioning Resilience; Need of a Paradigm Shift in Landslide Disaster Risk Reduction Process for Improving Social Resilience in Sri Lanka.

Dr. Pathmakumara Jayasingha, Senior Scientist Landslide Research and Risk Management Division

Landslide disaster risk reduction process that has been introduced and implemented in Sri Lanka does not adequately address and discuss social sentiments and hence, it needs an intellectual input and immediate advancement. It is no wonder that wellbeing of social sphere has been often neglected and ignored in disaster risk reduction process of the country. Landslide is a geological phenomenon, which most impacted and vulnerable communities are poorly aware of, and the causes of the hazard and post-disaster consequences are not very well-known. This aspect has been noted and the protests of communities when their social sphere is crossed by the landslide disaster risk reduction plans have proven this in many occasions.

Cultural behaviors and social relationships which have been resulted from establishment of long term experiences are highly important for local communities. Whilst the material culture is more concerned in the context of western science, spiritual and ethereal culture dominates in the eastern world. Hence, application of western born, so called "scientific techniques and methods" in landslide disaster risk reduction to fit the Sri Lankan culture is quite questionable and that has not been realized yet.

It can be understood that exploring local traditions and traditional techniques are very important in landslide disaster risk reduction process. Understanding the ethics, sentiments and mental state of the affected and vulnerable people should be the prioritized activity although it is not a serious concern at present. The mental stress and the depression developing in the affected and vulnerable people must be taken into consideration in any plan of post disaster risk reduction process. Counselling and mental therapy based on local traditions should be introduced and applied wherever it is necessary because it is well understood that only the materialistic approaches are insufficient in post disaster risk reduction process.

Implementing agencies of disaster risk reduction must be smart enough to improve the social resilience of vulnerable communities for which the application of social geology, a newly developing sub-field of geology is a suitable approach. Social geologists, who are unique and specific, are capable of handling and relating both to science and sentiments of people. Involvement of social geology in landslide disaster risk reduction can be a huge step in improving the social resilience of Sri Lanka.

Reference :

Jayasingha P. 2016. Social Geology and Landslide Disaster Risk Reduction in Sri Lanka. Journal of Tropical Forestry and Environment. 6(2).

Sources of Ground Vibrations and Control Methods to Overcome Hazardous Impacts

T.R Shamitha Thushan Wijewardana, Scientist, Human Settlements Planning and Training Division

With the rapid development of the construction industry during the recent years in the country, usage of vibration related technologies and machineries for various construction activities has become a day to day practice. When considering about the vibration related activities, they can be classified under the following major categories.

- Whole body vibrations
- Hand arm vibrations
- Ground vibrations
- Blasting activities

Whole body vibrations (figure 1) are created by the use of construction machinery such as road rollers. Hand arm vibrations (figure 2) are created when using hand-held equipment such as hammer drills. Ground vibrations (figure 3) are a result of using heavy construction machinery in activities such as pile driving and in-vibro ground improvement techniques.

This article mainly focuses on the sources of ground vibrations in the construction industry, impacts of ground vibration and control methods that can be applied. In Sri Lanka, major sources of ground vibration can be identified as blasting activities, pile driving activities, heavy excavation activities, heavy vehicle movements, crushers, vibratory sieves, compressors and generators in mega constructions. People suffer from many discomforts due to vibration induced by construction activities such as pile driving. Adjacent

Figure 1: Whole body vibration

Figure 2: Hand arm vibration

Figure 3: Ground vibration

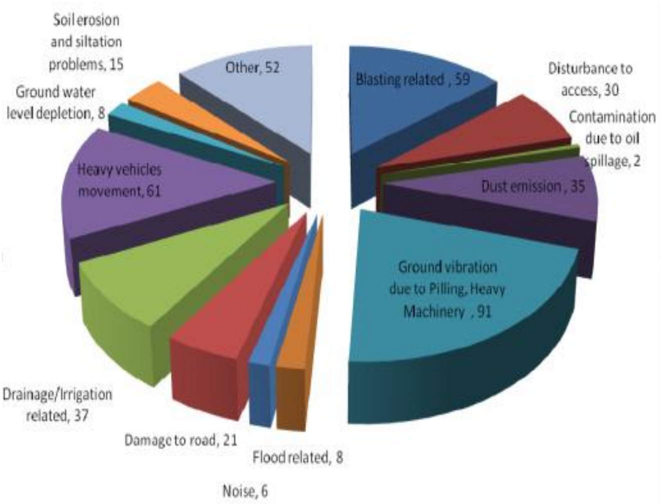


Figure 4: Complaints received up to december 2008 in the Southern Transport Development Project (STDP 2008)

Buildings are also subjected to crack formation, existing cracks in such buildings may propagate and become enlarged and partitions become detached from load bearing walls or floors due to heavy vibrations. Many public complaints and protests are raised because of vibration due to pile driving. In the Southern Transport Development Project, by the end of December 2008 the contractor received 424 complaints (Figure 4). According to Figure 1, complaints due to pilling and blasting are higher when compared with other activities. It indicates that vibration induced by piling has become a significant problem to people living close by as well as structures in the vicinity. It can be further identified that bored piling induced low magnitude high frequency ground vibration and impact piling induced high magnitude low frequency ground vibration. Magnitude of ground vibration induced by bored piling and impact piling decay with the distance from the source. Higher frequency range of ground vibration was found with bored pilling compared to that of impact piling. In bored piling it was found the vertical ground vibration is dominant throughout the distance from the source. In bored piling, magnitude of the ground vibration induced during the excavation of soft soil is lesser than that during the excavation of hard rock in transverse, vertical and longitudinal wave. Therefore, need of effective control methods for damping vibrations have become a necessary requirement for the sustainable development of the construction industry.

Comparative Parameters and Standards

In Sri Lanka, (CEA) Central Environmental Authority is the responsible authority which provides the required guidelines and limitations regarding ground vibration caused by construction activities. Before commencing any vibration related activity, it is recommended to monitor ground vibration exposure levels and apply necessary control methods.

Table 1: Categorization of structure according to the type of building

Category of the structure of the building		Description
Resistance to the vibration decreasing	Type 1	Multi storey buildings of reinforced concrete or structural steel, with in filling panels of block work, brick or precast units not designed or resist earthquakes
	Type 2	Two-storey domestic houses & buildings constructed of reinforced block work, precast units, and with reinforced floor & roof construction, or wholly of reinforced concepts or similar, not designed to resist earthquakes.
	Type 3	Single and two story houses & buildings made of lighter construction, using lightweight materials such as bricks, cement blocks etc, not designed to resist earthquakes.
	Type 4	Structures that, because of their sensitivity to vibration, do not correspond to those listed above 1,2 & 3 & declared as archeologically preserved structures by the Department of Archaeology

Initially, type of the structure has to be selected from the details shown in Table 1, by considering the existing structural features of the relevant structure. According to the type of the relevant structure and the type of the ground vibration in that relevant region, frequency of the vibration and the limitation for peak particle velocity (PPV) of the vibrations can be obtained from Table 02. Vibration monitoring activities can be carried out by using a standard seismograph and the actual ground vibrations that are induced as a result of relevant vibration activities can be obtained from the seismograph readings (actual frequency and PPV). Those readings can be compared with the above described values in Table 02 and those measured PPV values should be comparatively less than the values shown in Table 02. If not, relevant control methods must be applied and until that time relevant vibration activities should not be carried out further.

Table 2: Interim Standards for Vibration of the Operation of Machinery, Construction

Category of the structure as given in Table 1.1	Type of Vibration	Frequency of Vibration (Hz)	Vibration in PPV (mm/Sec.)
Type 1	Continuous	0-10	5.0
		10-50	7.5
		Over 50	15.0
	Intermittent	0-10	10.0
		10-50	15.0
		Over-50	30.0
Type 2	Continuous	0-10	2.0
		10-50	4.0
		Over 50	8.0
	Intermittent	0-10	4.0
		10-50	8.0
		Over-50	16.0

Type 3	Continuous	0-10	1.0
		10-50	2.0
		Over 50	4.0
	Intermittent	0-10	2.0
		10-50	4.0
		Over-50	8.0
Type 4	Continuous	0-10	0.25
		10-50	0.5
		Over 50	1.0
	Intermittent	0-10	0.5
		10-50	1.0
		Over-50	2.0

Control Methods

Wave barriers

It is often suggested that ground vibrations can be interrupted using wave barriers. This concept is attractive, but the execution of an effective barrier system is difficult and expensive. The principle of operation of a barrier is to reflect wave energy back toward the source or absorb energy while preventing energy from propagating beyond the barrier towards a target building or other vulnerable structures.

It is found that, if an empty trench is used as an effective wave barrier (one that reduce vibration by about 88%), it must be at least two-thirds of a wave length to screen a seismic surface wave. The length of the barrier usually must be at least equal in depth to one wavelength of the incoming waves to screen even a small area. It was also found that solid concrete barriers with appropriate sizes also be effective, but in no case as effective as an empty barrier of same size.

Permanent and temporary vibration controlling methods

Permanent vibration barriers are effective for controlling long term vibration such as traffic induced vibrations. In such a case permanent wave barrier can be used which is filled with vibration damping waste materials. However, in the case of piling induced vibration, it is a short term vibration. Therefore, it is effective and economical to go for short term vibration controlling methods.

Therefore, applying a trench that will be filled with various types of damping materials, that can be also bio degradable, will be a best effective control method. The control techniques can be applied at three positions; near to the source, near to the receiver and in the middle of the path of propagating the vibrations (Figure 5). Also refer figures 6 and 7 which indicate a model to check the effectiveness of a trench filled with waste rubber.

When considering about the research related effective control methods throughout the past decade, trench system can be identified as the best and effective control method. However, the applicability of a trench in modern day construction sites may cause several additional problems due to the insufficient land spaces. Another major control method available can be identified as damping the vibrations at the source. In order to fulfil that requirement, highly developed vibration damping machineries have to be used for the construction activities related to heavy vibrations. As a developing country it is difficult to purchase such developed machineries to our construction industry due to higher cost. Therefore, contractors tend to use low cost machineries and lower quality machineries in order to fulfil construction requirements. Furthermore, considering all the above facts relevant to the construction industry in Sri Lanka, designers and developers also have to pay their attention towards the ground vibrations that are induced from vibration related activities. From the designer's point of view, they could design the structures so that there are enough spaces around the structures to apply wave barriers and trenches filled with vibration damping layers.


Figure 7: Reference wall


Figure 6: Wall with rubber trench

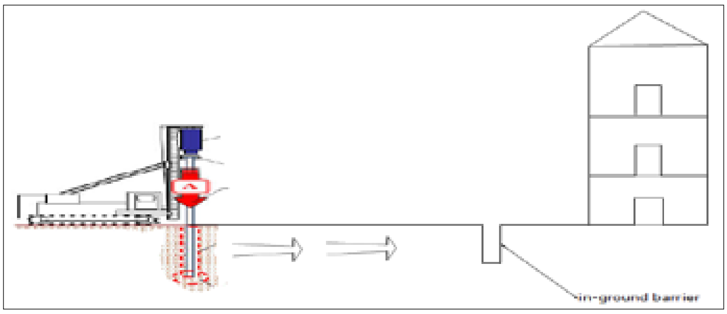


Figure 5: Application of in-Ground Barrier

Awareness Workshop on the National Landslide Resettlement Programme - Kalutara District

National Building Research Organisation (NBRO) is implementing a project titled "Training and Awareness on Disaster Resilient Housing Construction" to enhance resilience capacity of vulnerable communities It is April 2018 in collaboration with the Ministry of Public and implemented from administration Disaster Management, National Disaster Relief Service Centre (NDRSC) and the United Nations Development Programme (UNDP).

Under this project, series of awareness programmes has been conducted in Rathnapura, Kalutara, Galle, Matara and Hambanthota, districts Awareness programmes have been conducted for different target groups such as senior government officers, divisional NDRSC officers, technical officers, masons and the public.

Developing Building Codes for Resilience - Sri Lanka World Bank

The National Building Research Organisation (NBRO) and Construction Industry Development Authority (CIDA) have initiated development of building code for Sri Lanka and have requested technical assistance from the World Bank's expertise to develop building regulations for resilience. Accordingly, a World Bank Mission consisting of multi-disciplinary experts visited Sri Lanka last year.

Industry Consultation Programme 2019

National Building Research Organisation (NBRO) contributes to make safer built environment through promoting research and development programmes and providing technical services for disaster risk reduction through its services in the fields of Geotechnical Engineering, Building Materials Research and Testing, Environmental Studies Project Management and Human Settlement Planning. As per the tradition NBRO this year also conducted annual Industrial Consultation Programme to identify research needs of the industry for the next R&D programme. This year programme was successfully held on 29th January 2019 at the Renuka City Hotel, Colombo 3.

This programme witnessed with the participation of many industry and stakeholder institutions and invited government authorities. Participants were first informed about the ongoing R&D programme at NBRO. Later, at the consultation participants discussed R&D needs in industry with special reference to the needs of institutions they represent. They also expressed their views on R&D needs in the country and what they expect from NBRO. Later, these industry needs and views expressed were conveyed to NBRO scientists encouraging them to formulate suitable R&D project proposals for the next NBRO R&D Programme.

NBRO holds 9th Annual Research Symposium.......

"Innovation for Build Back Better"

Annual Research Symposium - 2018 on "Innovation for Build Back Better" organized by National Building Research Organisation (NBRO) was successfully held on 18th and 19th December 2018 at the Grand Ballroom of the Galle Face Hotel, Colombo.

This graceful event witnessed the participation of many researchers, disaster management practitioners, policy makers and eminent experts from local and international institutions. It provided an excellent platform to have discussions, exchange ideas and share experience.

During the Inaugural Session, Eng. (Dr.) Asiri Karunawardena, Director General of NBRO delivered the welcome address. Thereafter, Eng. N. A. Sisira Kumara, the Secretary to the Ministry of Irrigation and Water Resources and Disaster Management addressed the audience. Then the Landslide Risk Profile database was launched. This database covers 10 landslide-prone districts at the divisional secretariat level. The keynote speaker Dr. Farrokh Nadim, Technical Director, Norwegian Geotechnical Institute (NGI) delivered an eye-opening keynote address on "Managing landslide and other natural hazard risks: Lessons from the European Safe Land Project". Afterwards the symposium proceeded, holding six structured technical sessions chaired respectively by Dr. U. P. Nawagamuwa, Dr. J. S. M. Fowze, Prof. S. U. Adikary, Dr. Prasanna Ratnaweera, Dr. (Mrs.) B. C. Liyanage Athapattu, and Prof. Tilak Hewawasam, on the following themes.

- Emerging technologies for safer built environment
- Preparedness for effective response
- Innovations for sustainable building materials
- Engineering approaches for resilience
- Environmental adaptation for sustainable development
- Recovery, rehabilitation & reconstruction

There were two panel discussions and the first panel discussion on "Nature Based Solutions for Landslide Risk Management" was held on 18th chaired by Mr. N. M. S. I. Arambepola as the Moderator and with Dr. U. P. Nawagamuwa, Mr. H. M. U. Chularathne, Dr. Pathmakumara Jayasinghe and Ms. Priyanka Dissanayake as panelists. The second panel discussion was held on 19th on "Sri Lanka's approach towards resilient built environment: Are we on the right path towards Building Back Better?", chaired by Ms. Florita Gunasekara as the Moderator, and with Eng. (Dr). Asiri Karunawardena, Dr.William Cheang. Dr. Farrokh Nadim, Prof. C. Jayasinghe, Col. Sudath Madugalle, and Dr. Athula Senaratne as panelists.

NBRO wishes to thank the resource persons, the distinguished invitees and the large gathering of participants who made this event so successful to the end and hopes to hold the tenth annual research symposium even better, in 2019. (download Symposium Proceedings)

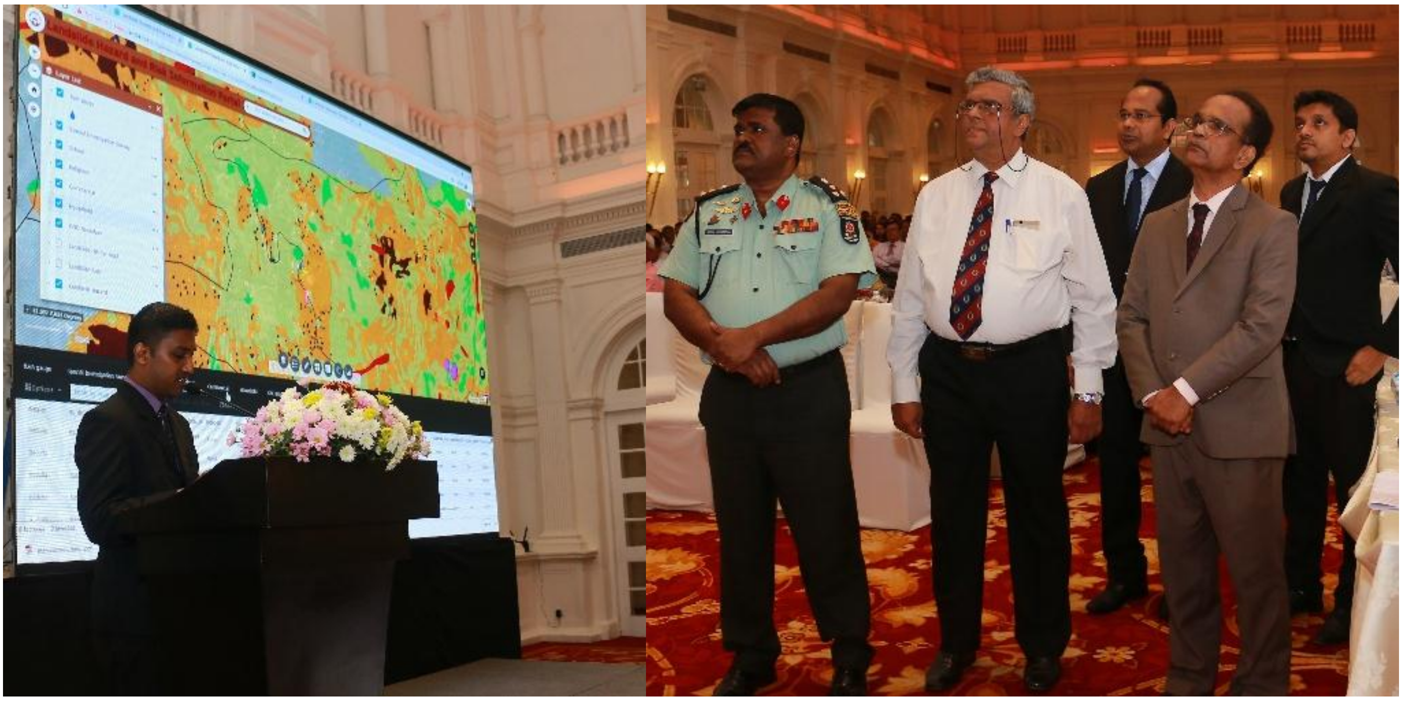
Inauguration: Ms. Monica Svenskerud the Senior Adviser of Royal Norwegian Embassy in Sri Lanka lighting the traditional oil lamp while distinguished invitees looking in.

Dr. (Eng.) Asiri Karunawardena, the Director General of NBRO delivering the Welcome Address

Eng. N A Sisira Kumara the Secretary of the Ministry delivering the Address of the Chief Guest

Dr. Farrokh Nadim, Technical Director of Norwegian Geotechnical Institute delivering the Keynote address

Official launching of the Symposium Proceedings



Launching of Landslide Risk Profile database by senior officers concerned

Panel Discussion on day - 1

Panel Discussion on day - 2

Part of the Audience

National Building Research Organisation
99/1; Jawatta Road, Colombo 5
Email : nbro@sltnet.lk | Web site : www.nbro.gov.lk | Tel : (011) 2588946 | Fax : (011) 2502611