National Building Research Organisation

NBRO Newsletter

A Special Edition on NBRO 2019 Highlights

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10TH ANNUAL RESEARCH SYMPOSIUM - 2019

NBRO SYMPOSIUM

Cover Image: Ambadeniyawatta Resettlement Site - Mawanella (Kegalle District)

Dear Readers...

We are proud to welcome you to read the 2019 Special Edition of the NBRO Newsletter which covers the Key activities initiated by National Building Research Organisation (NBRO) during the year 2019.

Over the past thirty five years, NBRO provided a platform to policy makers, professionals, scholars and practitioners to discuss and share their views and experiences on emerging building technologies, settlement planning, and Disaster Risk Reduction.

As such, this year also NBRO engaged in numerous research and development activities which aimed at creating a safer built environment. Hence, we are happy to invite you to read this Newsletter published concurrent with the 10th Annual Research Symposium 2019 of the NBRO. This presents a myriad of articles on the subjects of DRR, resilient housing, building materials, and sustainable environment etc.

We sincerely hope that the readers will enjoy reading this edition of Newsletter. We welcome your feedback and ideas for future actions of NBRO.

Eng. (Dr) Asiri Karunawardena
Director General

Consultancies on Slope Stability, Compaction, Gas and Leachate managemet for Rehabilitation of Waste Disposal Site at Meethotamulla

Government of Sri Lanka later decided to rehabilitate and develop the waste dump as a recreational area. Consequently, NBRO has been providing guidance and consultancies

Meethotamulla solid waste disposal site is one of the unregulated Municipal Solid Waste Management facilities in Sri Lanka located at Pothuwilkumbura, Meethotamulla, Kollonnawa. The disposal site is discontinued from receiving waste followed by a catastrophic ground failure of the waste mound on 14th April 2017 completely destroying houses and infrastructure situated at the South-Western (SW) side toe region of the garbage mound. According to the situation report of "Methotamulla Municipal Solid Waste Dump Disaster" by Disaster Management Center, 60 houses had been completely destroyed, 27 houses partially damaged while 32 bodies have been recovered from the devastated area. The Meteorological Department weather report indicates that this catastrophic failure had occurred after an intense rainfall of over 100mm spelled from 11th – 13th April 2017.

Fig. 1: During Rehabilitation Process

Soon after the disaster, a team of experts of National Building Research Organisation (NBRO) visited the site to investigate the existing situation, and to elucidate the probable cause of failure, and also to identify in remedial actions to prevent a further catastrophe. Government of Sri Lanka later decided to rehabilitate and develop the waste dump as a recreational area and commenced a rehabilitation program since year 2017. Consequently, NBRO has been providing guidance and consultancies on ;

(1). Slope stability and compaction processes by ensuring the achievement of targets of mitigation measures in accordance with proposed design and specifications. In addition, NBRO is also tackling possible construction issues and recommending technical solutions in collaboration with the client. Full time supervision of construction work

(2). Landfill gases and leachate management

The management plan of the landfill gases has mainly four phases as,

1. Trials of the of the gas extraction and leachate collection systems
2. Before the commencement of the rehabilitation work,
3. During the rehabilitation work, and
4. After completing the rehabilitation work

Detailed Geotechnical Investigation for Flood Control in Kelani River Basin

The Government of Sri Lanka is currently implementing Climate Resilience Improvement Project (CRIP)- Consultancy Services for Development of Basin Investment Plans (DBIP) (Flood and Drought Risk Mitigation Investment Plans) to protect Colombo and its suburban area from flooding. National Building Research Organisation (NBRO) has been selected by CRIP as qualified contractor to execute the main geotechnical investigation including drilling, Piezocone testing, geotechnical laboratory tests, installation and monitoring of standpipes and piezometers for further monitoring activities and preparation of factual and interpretative geotechnical investigation reports.

The study area lies within the floodplain of Kelani River from Kaduwela to Hanwella, where the meandering stage of the river prevails. Considering the geomorphological conditions, it can be stated that, the terrain is unconfined, plainer with slightly undulating ground surface. The floodplain extends few kilometers either sides of the river. The preliminary investigation program was carried out covering the proposed embankment trace, which has been developed considering flood defenses with a centerline up to 50 feet from the river bank.

Upon the completion of investigation program within the given time period and expected quality, a comprehensive engineering and geological interpretation of geotechnical units has been carried out, which can be utilized for designing flood mitigation and control programs.

Fig. 1. Truck mounted CPT rig

Fig. 1. Proposed Mitigation Site in Ayagama

Reduction of Landslide Vulnerability by Mitigation Measures Project (RLVMMP)

The recent landslides occurred in 2003, 2007, 2010, 2011, 2014, 2016 and 2017 that alone have taken away nearly 1000 human lives and caused huge losses to the economy. The various efforts and countermeasures demonstrated so far to mitigate landslide disasters are far from the adequate. Damage to property and infrastructure investment lost on national development were enormous in monetary terms. In this regard, Sri Lanka has given a high priority for investment on landslide mitigation expecting to reduce costs of relief, rehabilitation and reconstruction, and in addition to prevent the loss of investment on sustainable infrastructure development.

National Building Research Organisation (NBRO) forwarded the project proposal to the Asian Infrastructure Investment Bank (AIIB) to obtain funding assistance for mitigating/rectifying unstable slopes in high risk areas. The project will implement mitigation measures to protect the key infrastructures in the area, such as railway track, highways, roads, public buildings and other utility services and to ensure the safety of communities from more frequent landslides. Accordingly, 147 landslides have been identified for mitigation activities from 11 districts countrywide. Further, the capacity of NBRO will be enhanced in strengthening existing rules, regulations and practices to this effect.

Guidelines on Structural Appraisal of Existing Reinforced Concrete & Masonry Buildings in Sri Lanka

The main objective of this guideline is to establish a general methodology for structural appraisal of existing reinforced concrete & masonry structures

National Building Research Organisation (NBRO) is presently conducting a dynamic government-funded research and development programme. NBRO conducts building appraisal as day to day work and has set in-house procedures in this respect. Having realized NBRO's potential, stakeholders at the last Annual Industry Consultation Meeting held in February 2019 requested NBRO to develop a suitable guideline on building appraisal. In response, Project Management Division of NBRO launched a research project on this subject and this research project leads to the preparation of a suitable technical guideline for construction industry on building appraisal by NBRO staff.

The main objective of this guideline is to establish a general methodology for structural appraisal of existing reinforced concrete & masonry structures, mainly for the benefit of engineers who are engaged in the structural appraisal of existing buildings. Hence, as the outcome of this project "Guidelines on Structural Appraisal of Existing Buildings with Reinforced Concrete & Masonry Structures in Sri Lanka" will be developed. Experts from industry and academia as consultants extend necessary assistance to the compilation of said guideline.

First Reviewing Committee meeting was arranged on Tuesday 26th November 2019 at 2.00 p.m at the Auditorium at NBRO. Reviewing Committee commented to improvement the draft document.

NBRO joins with JICA to conduct Research on Rain-Induced Rapid and Long-Travelling Landslides

National Building Research Organisation of Sri Lanka and the Japan International Cooperation Agency (JICA) agreed to implement a project under the SATREPS, which is on Development of early warning technology of rain-induced rapid and long-travelling landslides in Sri Lanka (RRLL).

Science and Technology Research Partnership for Sustainable Development (SATREPS) is a partnership aims to develop new technologies and their applications for tackling global issues, and also

Landslide Risk Information Portal

Landslide Risk Information Portal anticipate to visualize the characteristics of the landslide vulnerable communities among the disaster risk management authorities for decision making purpose.

Landslide risk profile development project is implemented by National Building Research Organization (NBRO) with the financial assistance of Government of Sri Lanka. This project was initiated to meet the outcome – 1 of Sri Lanka Comprehensive Disaster Management Programme (SLCDMP) 2014-2018, "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". Objective of this project is to develop a spatial database of the communities, expose to landslide hazard. Spatial distribution of buildings expose to landslide hazard are identified using 1;10,000 scale landslide hazards maps prepared for the Grama Niladari Divisions. Data collection was conducted on housing units, commercial/ institutions, religious places and schools, which are located within very high and high landslide hazard prone areas. Landslide Risk Information Portal anticipate to visualize the characteristics of the landslide vulnerable communities among the disaster risk management authorities for decision making purpose. It involves web-based Geographic Information System, which offer opportunity of maintaining both statistical information combined with geospatial data. In order to assess the potential losses and degree of damage of buildings that are exposed to a certain type of hazardous event, it is important to define the characteristics of the building. There are different user levels and general users will be able to access only for the basic details, the authorized users who wish to obtain more information shall log in via admin login tab. The portal cloud be logged via NBRO web page (www.nbro.gov.lk).

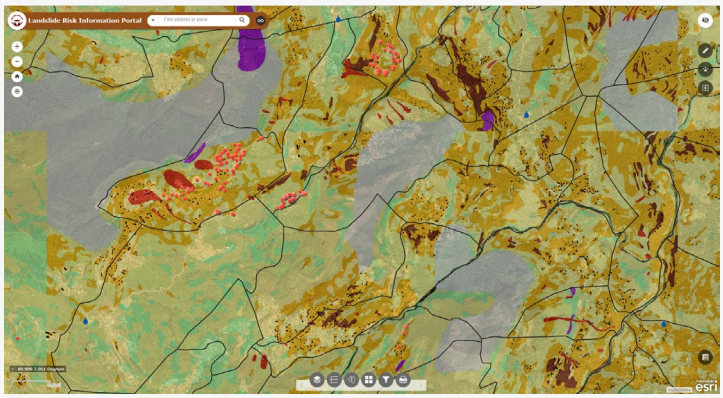

Fig. 1. Main User Interface of the Landslide Risk Iformation Portal

NBRO Introduces Japanese Concept of Yellowzone and Redzone in to Landslide Hazard Zonation Map

National Building Research Organization (NBRO) and Japan International Cooperation Agency (JICA) have implemented a 4-year project named "Technical Cooperation for Landslide Mitigation Project (TCLMP)" in 2014- 2018 in order to strengthen the capacity on structural measures for landslides, slope failure and rock fall in Badulla, Nuwara Eliya, Kandy and Matale districts. However, to protect people facing landslide risk in local area, it is necessary to further promote non-structural measures such as developing effective early warning system and land use regulation. Those should be based on "site-specific" hazard and risk assessments. Under these circumstances, NBRO and JICA launched the "Project for Capacity Strengthening on Development of Non-structural Measures for Landslide Risk Reduction (SABO)" in February 2019 as a three-year project.

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at capacity development of researchers and research institutes in both Japan and a recipient country.
A detailed planning survey for the project was agreed and signed between NBRO and JICA on 15th October 2019.

In addition, a Collaborative Research Agreement was also signed on 15th October, 2019 between NBRO and International Consortium on Landslides (ICL) for **"Development of early warning technology of rain-induced rapid and long-travelling landslides in Sri Lanka"** that is implemented under the "Science and Technology Research Partnership for Sustainable Development (SATREPS)" funded by JICA and Japan Science and Technology Agency (JST).

Fig. 1. Signing of Research Agreement

Celebration of 7th Year of Technical Cooperation between NGI-NBRO

The ongoing institutional technical cooperation project between Norwegian Geotechnical Institute (NGI) and NBRO titled as "Technical support for Mitigation of Natural Disasters due to Climate Change in Sri Lanka" celebrates the 7th year of technical cooperation to this November, 2019. Project was started on 2012 November for identifying of land subsidence issues in Matale area and, NGI donated the Ground Penetrating Radar (GPR) technology to NBRO for identifying of ground cavities in the problematic areas. Different types of antennas were developed for different applications; bore-hole tomography, reinforcement assessments in buildings. The InSAR technology was also used to remotely monitor the subsidence issue over long period of time and automated rain-gauges were donated to NBRO for acquiring the rainfall measurements in real-time basis.

Unmanned Arial Vehicle (UAV) based mapping technology was introduced to NBRO under this project in 2014 during the Meeriayabedda Landslide event and, 2 no of high-end computers with processing software were donated to NBRO for ensuring of sustainability of the project. Since, then NBRO utilize such system to rapid assessment of landslide incidents and the detailed investigations were published in NBRO website. In addition, NGI helped NBRO for resolving the oil contaminated water issues in Chunnakam, Jaffna. Recently, this GPR technology was linked to the detection of ancient ramparts in world historic city of Anuradapura to support Archeological department of Sri Lanka.

With this success, NGI-NBRO collaboration will continue in the coming years for mitigating future climate change induced disasters in Sri Lanka.

Fig. 1: GPR Demostration

Fig. 2: GPR Field Surveys

Technical Guidelines on Building Demolition Work in Sri Lanka by NBRO

Unavailability of statutory technical guidelines, codes, safety standards or regulations and lack of involvement of relevant professionals in planning & direction, monitoring & supervision in ensuring safety of life and property, appeared to have been the main reasons for series of tragic incidents recently associated with building demolition work in Sri Lanka.

This guideline was prepared to provide guidance on safe and good practices for demolition works. Current practice of building demolition projects is mostly done using the experience of the contractor. Introducing this guideline would make them aware of the technical approach to the demolition activities.

This document contains basic information for the practitioners on better planning and control when carrying out demolition work. Preparation of these Guidelines was initiated by the National Building Research Organisation, through a Working Committee consisting of senior Academics, Professionals and Scientists in the field of construction.

In the absence of any national guidelines on building demolition already published in Sri Lanka, several international documents on building demolition that were referred to in detail during the preparation of this Document.

Fig. 1: Demolition Work Using Machinery

Fig. 2. Demolition Work Using Machinery

Subsurface Geological Geotechnical Model for Disaster Resilient Housing in Colombo MC

National Building Research Organisation (NBRO), initiated a research to develop a 3D Subsurface Geological and Geotechnical Model for Disaster Resilience Housing in CMC using the available borehole data.

Construction activities are crucial for the economic development of a country and these activities cannot be implemented successfully without policy makers paying attention to the geological factors of the region. There are several factors needed to be taken in to account when selecting the land for certain constructions such as suitability of the land, capital cost of investment, available infrastructure, total consumable area and subsurface condition. Among them subsurface condition plays a key role because planning, site preparation, and footing design for a new construction are carried out according to the subsurface conditions. Also, it is required when evaluating the soil condition under existing structure when making expansion or in remediation of post construction problems.

However, there is no pre-defined method to obtain subsurface conditions without a borehole investigation or geophysical survey. Borehole investigation and geophysical surveys are expensive and time-consuming. In this regard, visualization of subsurface soil properties can become greatly advantageous since it shows spatial trends that can be used to select new borehole locations and reduce the total number of boreholes needed.
After identifying the need of a subsurface geological and geotechnical database for Sri Lanka, National Building Research Organisation, initiated a research to develop a 3D Subsurface Geological and Geotechnical Model for Disaster Resilience Housing in CMC using the available borehole data. CMC was selected as study area, since a proposal had been put forward to develop Colombo as a metropolitan city.
The borehole geo-database and the pre prepared geo-sections can be accessed through a web-based interface for potential stakeholders.

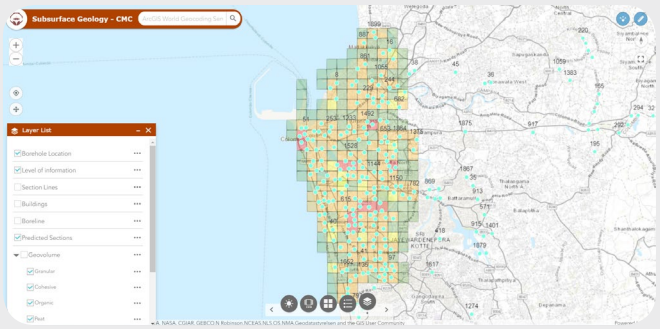

Fig. 1. Level of Information as Shown UI

Fig. 2. Geo-Section Layers as Shown on UI

Government Grant Landslide Mitigation Project

During the last few years more than 35 landslide sites surrounding public places such as hospitals, schools, villages and sites along the major roads have been mitigated under the above project

According to the studies carried out by the National Building Research Organisation (NBRO), there are 14 landslide prone districts that have been identified as having high-risks areas, with unstable slopes in need of immediate mitigation or protection measures. The districts include Badulla, Rathnapura, Kegalle, Kandy, Nuwaraeliya, Matale, Matara, Kaluthara, Hambantota, Kurunegala, Moneragala, Gampaha and Colombo. In fact, following the catastrophic landslides events which happened in last two decades the Government has given highest priority to mitigate threats posed to life, property, transport, infrastructures and to the economy of the districts and to the country as a whole.

Accordingly the government has allocated 200 million rupees in every year to conduct landslide mitigation activities in the above landslide prone districts since 2014. This landslide mitigation project for stabilizing landslide sites namely “200 MRs Government Grant Project” that is implemented by the National Building Research Organisation (NBRO) under the Ministry of Public Administration Disaster Management and Livestock Development (MPADM&LD).

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Landslide Early Warning System in NBRO

As Sri Lanka is located nearby the equator, atmospheric disturbances occur frequently in a random manner. Therefore, Sri Lanka receives rainfall throughout the year. Heavy rainfall stimulates the severity of landslide risk on convex and concave slopes. The rainfall events above the normal are considered as rainfall events highly impacting on landslides. These landslides fall in to three categories; slope failures, debris flows and cutting failures. Slope failures (natural slides) occur as a result of a heavy rainfall. Cutting failures can take place at a very small rainfall. Even debris flows (moving mass of loose mud, sand, soil, rock, water and air travels down a slope under the influence of gravity) occurs with a small rainfall.
As the national focal point for landslide risk management, NBRO conducts identification, investigation, hazard mapping, monitoring, early warning and mitigation of landslides in the country. Rainfall is the main triggering factor for the landslide occurrences in Sri Lanka. Issuing landslide warnings is in two scales; either on a "regional-scale" (large scale) or "site- specific". In regional-scale; forecasting and issuing general warnings are relying on the rainfall measurements/predictions of triggering event. In site specific scale; forecasting and issuing warnings rely on the measurements of the monitored landslide locations (limited to the monitored Landslides).

When issuing regional-scale early warnings, the rainfall variation is monitored by a network of 300 automated rain gauge stations and rainfall forecasted by the department of Meteorology are taken into consideration in predicting the occurrence of landslide based on derived thresholds by the previous studies. The three warning levels issued depending on monitored rainfall are: yellow colour- "Watch" (above75mm/day), amber colour- "Alert" (above 100mm/day) and red colour- "Evacuate" (above 150mm/day or 75mm/h).

The areas of landslide high-risk, intermediate-risk and low-risk areas have been identified by a landslide hazard zonation map according to research and pre-landslide records. This kind of zonation is very useful for standardizing the evacuation system to gather information about the areas people live in and resettle people in landslide risk free areas.

In site-specific early warning system, the warnings are issued by monitoring the mass movements of the ground using extensometers.
As it is more useful in giving early warnings for a large crowd, NBRO mainly focuses on regional (Local scale) early warning issuing based on automated rain gauge stations. Instead dependency on 24h (daily), 48h or 72h cumulative rainfall readings, currently the system has been improved to 10-day cumulative rainfall readings to enhance the system effectiveness.

Dissemination of early warning message plays a major role in landslide risk management and rescuing lives. This early warning message is distributed through emails in a standard format with a map attached with displaying warning standard colours with risky divisional secretariats in each districts. When this warning message is issued to the Disaster Management Centre, the message is broadcasted to the media from the DMC and given to district offices. From district offices, the message is passed to district secretariats, then to GN officers and then the evacuation message is passed to the villagers in relevant areas if at a critical stage.

If there are any possibilities to issue early landslide predictions based on rainfall amounts about few hours prior to the landslide event that will be very useful to early evacuation of the people living in vulnerable areas. Therefore, NBRO is carrying out several projects with staff members to issue better landslide predictions by improving the existing landslide early warning issuing system.

Fig.1: Automated rain gauge station

Fig.2: Distribution of Automated Rainfall Gauge stations

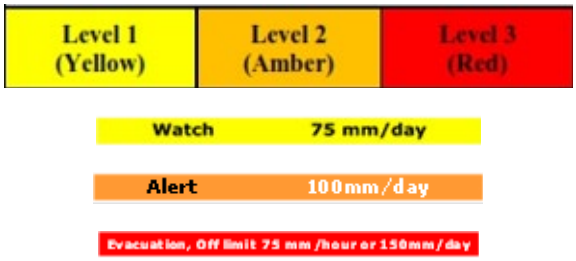

Fig. 3: Warning Levels

Cost-effective Structural System for Retrofitting Existing Houses in Flood Prone Areas

Intensity of the occurrence of natural disasters such as landslides, floods and high winds in Sri Lanka have increased during the last decade due to several natural and manmade reasons. Disaster statistics show that in 2017, flood hazard was triggered by heavy rain at the onset of the southwest monsoon on 25th and 26th May affecting 879,778 people with 219 deaths and 74 missing. The disaster caused destruction and damaged nearly 80,000 houses and affected livelihood of over 342,000 people. This was a long-term issue for the government due to the loss of lives, loss of livelihoods and economic activities. Other than that, after each disaster event, the government spent vast sums of money for response and recovery. With that background, National Building Research Organisation initiated a research study on "Safer Communities with Hydro Metrological Resilient Houses" in collaboration with University Bath, United Kingdom and University of Moratuwa in April 2019. This study focused on retrofitting an existing housing unit, located in flood prone zone with a refuge space, enabling the residents to safely stay during a flood disaster, protecting their properties and strengthening the housing structure with disaster resilient features.

For this purpose, an existing housing unit in Bulathsinhala Divisional Secretariat Division, Kalutara district, was selected by a proper evaluation to provide insights on their structural design requirement for the proposed retrofitting. Awareness workshop was conducted at IESl on 21/11/2019 and the opeining ceremony of the model house was held on 22/11/2019 with the participation of the research team and the government officials of Bulathsinhala DSD.

Constructed Refugee Space

Retrofitted Walls

Final Workshop

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Cont... Government Grant Landslide Mitigation Project

During the last few years more than 35 sites including public places such as hospital, schools, villages and sites along the major roads (Figure 01, and 02) have been mitigated within the above landslide prone districts under the above project. The following eight locations have been selected to conduct landslide mitigations activities in this year 2019.

Fig.1: Lankagama Kanishta Vidyalaya

Fig.2: Kadugannawa Tamil College

Fig.3: Ayagama Hospital

Design Studio Workshops for University Students

NBRO conduct training programmes and design studio workshops for university students, military officers, medical officers and etc., on Disaster Risk Reduction, Disaster Resilient Settlement Planning, Disaster Resilient Constructions, Building Material Testings and relevent subject areas. One such programme was conducted recently for local university students. The 1st design studio on above conducted at the Nivithigala, Dombagammana Resettlement site of Ratnapura District. The site is one of the well-planned resettlement site of the Ratnapura district which has accommodated 120 victims of 2017 landslide and flood disaster.

The 2nd workshop was conducted in Meeriyabedda resettlement site where 75 houses have been constructed after the Meeriyabadedda disaster in 2014.

The workshop included on site lecturing and field surveys. NBRO's Town Planning professionals, engineers, architects and Landscape Architects joined the workshop as resource persons.

Fig. 2. Workshop at Nivithigala

Fig. 3. Workshop at Sooriyawewa

Fig. 1. Workshop at Nivithigala

Fig. 2. Workshop at Nivithigala

From Page 5

Cont... Yellowzone and Redzone

Under this project a methodology has been used to determine site specific hazard zones, which is authorized in Japan. In this methodology landslide hazard area (Yellow zone) and landslide special hazard area (Red zone) are drawn using certain morphometric rules defined based on statistical analysis. Accordingly Yellow zone & Red zone can be defined as follows.

A "zone with danger of harm" (Yellow Zone) defined as an area prone to sediment disaster. If an area is designated as a Yellow Zone: 1) early warning systems should be established, and 2) steps to raise the awareness of local people about sediment disasters shall be taken. A "zone with a considerable danger of harm" (Red Zone) is designated as an area where there is a serious risk of damage to buildings and threat to residents. If an area is defined as a Red Zone: 1) a license is required for land development for housing, etc.; 2) building certification is required for buildings; and 3) relocation of buildings that are vulnerable to serious damage in case of a sediment disaster is recommended.

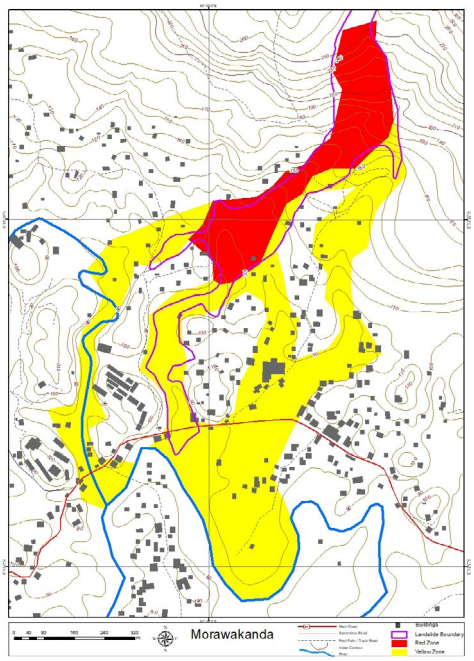

Fig. 1. Yellowzone Redzone Map

10TH ANNUAL RESEARCH SYMPOSIUM - 2019

NBRO SYMPOSIUM

The 10th Annual NBRO Symposium on "Equitable Resilience'' will be organized on 17th and 18th December 2019 at, Colombo as a tradition to propagate the outcome of NBRO's Research & Development and other related studies, on Equitable structural and nonstructural mitigations approach to Disaster Risk Reduction activities in Sri Lanka and it will provide pathways to incorporate disaster resilience into post-disaster recovery, rehabilitation and reconstruction process.

The keynote speech will be delivered by Prof. Terrence Fernando, Director of the THINKlab on the theme of Equitable Resilience. His major fields of work related to Urban Planning, Collaborative Engineering Workspaces, Urban Simulation, Future Media Platforms.

Disseminating Japanese Technologies for the Landslide Remote Monitoring System

Several kinds of natural disaster like sediment disaster and floods occurred due to the geographical conditions and the effect of climatic change in Sri Lanka. Therefore, national development has been affected by these disasters. According to historical records, many sediment disasters occurred due to heavy rainfall. In the mountains and hilly areas located in the central parts of the country, which accounts for 20% of the total territory and where 30% of the people live, landslides and steep slope failures frequently occur due to fragile geology and topographical conditions in such areas. Presently, the landslide early warnings are issued based on the amount of observed rainfall. The improvement of the landslide monitoring system and methods will contribute to disaster risk deduction of Sri Lanka. The purpose of this survey is improvement of the landslide early warning system to the following achievements of this purpose.

1. To install the Landslide remote monitoring system (LRMS) this is able to transmit onsite monitoring data using the radio communication network.

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Fabric Embedded Paving blocks for Footpaths

Fabric embedded paving blocks shows special features like water infiltration capability and shock absorption capability when compared with conventional cement based paving blocks.

Walking comfort of pedestrians is an essential consideration in the construction of foot paths or jogging tracks. Deformability and elasticity characteristics of fabrics can be used to develop cement based products with improved energy absorption characteristics.

In Sri Lanka synthetic fiber blended fabric offcuts considered as waste, creates a significant waste disposal problem. Currently it is being sent to a cement manufacturing plant where it is incinerated as fuel in the cement kiln or it will end up with illegal dumping in land fillings. Accordingly paving block was developed with the use of fabric waste as a result of research activities. Fabric embedded paving blocks shows special features like water infiltration capability and shock absorption capability when compared with conventional cement based paving blocks. Water permeability of polyester spandex fabric embedded paving blocks is 100 times higher than that of commercially available cement based paving blocks. This feature leads to reduce surface runoff during raining while recharging underground water table. This will be the solution to reduce instant flooding on open concrete areas during heavy rain.

The developed blocks were tested for shock absorption capability and its test results showed that force reduction percentage of fabric embedded paving blocks varies from 9% to 12%. Therefore, it is suggested that this paving block can be used for foot paths which gives better walking comfort.

Article By G.K.B.M. Gannoruwa, Building Material Research & Testing Division

Fig. 1. Fabric Embedded Paving blocks

An Underconstructing House in Morawakkanda

From a Tragedy to Renewed Hope - Housing for the Disaster Victims by Red Cross and SL Army

The Sri Lanka Red Cross Society, Sri Lanka Army along with National Building Research Organisation (NBRO) and Kotapola Divisional Secretariat Office are constructing 10 houses for the victims of Morawakkanda landslide which slide in May 2017. The houses are being built by the Sri Lanka Army with financial assistance from the Sri Lanka Red Cross Society. NBRO provides all necessary technical assistance including site layout plan, house plan, landscape plan and etc.. The settlement is being bult as a compact settlement cocept with detached two storey houses which is first of its kind for a landslide disater resettlement programme. The project is to be completed by the end December of 2019.

House Specifications

House Type	: Two Storey
Floor Area	: 650 Square Feet
Land Area per House	: 7 Perch Minimum
Total Houses	: 10 Houses

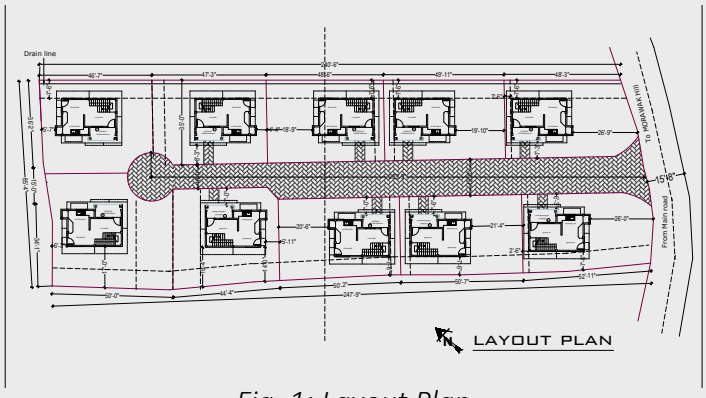

Fig. 1: Layout Plan

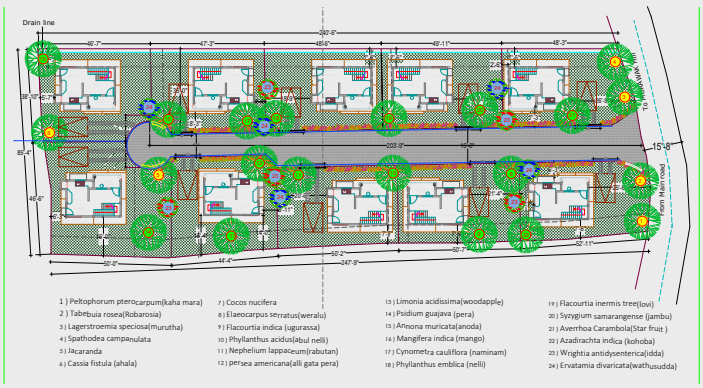

Fig. 2: Landscape Plan

Remarkable Increase in Ambient Air Pollution Levels in Colombo, Sri Lanka between 5th & 7th November 2019

The sudden remarkable increased levels of Particulate Matter levels can cause health problems depending on the concentration and time of exposure

NBRO ambient air quality measurement sites at Meteorological Department premises, Colombo 07 and Jawatta Road, Colombo 05 indicate that the ambient Particulate Matter (PM2.5 and PM10) levels have increased remarkably from 6:00 hours on 5th November 2019 which was below 40 $\mu g/m^3$ during the previous week. This remarkable increased of PM2.5 and PM10 levels up to the level of 50 $\mu g/m^3$ and 100 $\mu g/m^3$ m3 (which is the national standard levels for 24-hour average of PM2.5 and PM10 respectively) at about 8:00 am on 5th November 2019. The levels then further increased and reached up to the maximum levels at around 23:00 hour and changed slightly for several hours at relatively high levels till the evening of 6th November 2019.

The sudden remarkable increased levels of Particulate Matter levels can cause health problems depending on the concentration and length of exposures such conditions are assessed by comparing with the US Air Quality Index (USAQI), and summarized below are the colour code for different exposure levels.

The world air pollution map published by Air Visual (Switzerland) indicates that there is high pollution conditions in Indian peninsula and wind direction towards the Sri Lanka was in northern side. This condition may create situation for the flow of transboundary air pollutants from other countries from northern side of Sri Lanka. In addition, it could be due to stagnant and lower dispersion of air pollutants generated within the county due to the prevailing climatic conditions. The following images taken on 5th evening indicate the particulate pollution dispersion in the region including all areas in Sri Lanka. However, the high pollutant condition was changed with the changing wind pattern in 7th November 2019.

This type of sudden increase of air pollutant levels can damage the health of people severely. Although, the condition is temporary and short term, exposure to high pollutant levels for short period could cause health impacts especially for sensitive groups such as infants, pregnant ladies, old persons and who are having respiratory difficulties. The very high pollutant levels could cause hazardous situations which leads to disaster situation.

Therefore, with this condition, warning and guidance were given by NBRO with collaborating Disaster Management Centre (DMC) and Ministry of Health to take necessary actions and precautionary measures to reduce the impacts and prevent exposure of sensitive groups to poor air quality environment until the situation turns normal. Some of given guidance and precautions, to face similar situations happen in future, are summarized below.

Short term precautions:

1. Use of face masks if feeling breathing problems
2. Stay at indoor air-conditioned areas
3. Limit outdoor activities; sports, heavy work & gathering
4. Do not burn solid waste etc.
5. Reduce unnecessary travelling and make use public transport instead of personal vehicles.
6. Do not stay at high exposure areas such as roadside, close to industries, etc.
7. Stop using fire crackers and smoke, etc.

Long term precautions:

1. Provide and keep face masks in school bags to use when needed
2. Minimize traffic jams and vehicular emissions as much as possible
3. Provide instructions to industries to stop their emission sources such as generators, boilers etc.
4. Facilitate to improve air quality monitoring and management activities
5. Make aware the relevant institutes and agencies to prepare action plans to face similar situations
6. Limit usage of high emission vehicles

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects.
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected.

Fig. 1: US EPA Air Quality Index

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Cont... Disseminating Japanese Technologies

2. To confirm landslide determination based on several monitoring data such as extensometer, rain gauge and other instruments.
3. To support determination of the reference value of appropriate landslide early warning in NBRO

The basic concept of the LRMS is shown as follows,

1. The system transmit measurement data taken by observation instruments such as ground surface extensometers and rain gauges, installed in landslide risk areas to a management office located at a distance, in real time
2. The system monitors the onsite condition, evaluates the risk of landslide/slope failure and informs local residents of the risk at an early stage and urges them to evacuate.
3. The system is composed of observation instruments install on a slope (Ground surface extensometers, rain gauges, ground water gauges, strain gauges and multipoint inclinometers) and networking equipment (Radio transmitter, Communication devices, alarm devices and cloud service)

This project has been partly completed and receiving of real time data to NBRO is continued. It has been planned to complete this project in 2020.

Fig. 1. Piezometer

Fig. 2. Extensometer

Pre-Cast Disaster Resilient Housing for Landslide Victims

Initially as the Phase I of the project, 400 precast housing units will be constructed in Kalutara and Rathnapura districts

Intensity and frequency of the occurrence of natural disasters such as landslides, floods and high winds in Sri Lanka have increased during the past decade due to natural and manmade reasons. This has been a long-term issue for the government because of the loss of lives, loss of livelihoods and disruption to economic activities and especially because these disasters often cause the total or partial collapse of houses. Other than that, after each disaster event, the government spends large sums of money on response and recovery. Therefore, the government came up with a solution to resettle the people living in disaster prone areas in safer locations.

In this context, the government has given priority to identify families living at high risk in disaster prone areas and resettling them in safer areas as a sustainable solution for protecting them. There are about 14,000 such families identified by National Building Research Organisation at the risk of landslides alone. From 2016 onwards, the Ministry of Public Administra-

Drone Image: "Mirishena Resettlement Site of the Bulathsinhala DSD of Kalutara District. 42 houses are proposed to be constructed within 4 acres of the land. Capture date - 3rd December 2019.

tion, Disaster Management and Livestock Development implements the resettlement of these families with the Owner-Driven Approach. As this approach has been making a slow progress, the government decided to speed up the resettlement programme through the construction of pre-cast resilient houses. Accordingly, the project of "Construction of Pre-Cast Disaster Resilient Houses for the People Residing in Disaster Prone Areas" was launched in September 2019. Initially as the Phase I of the project, 400 precast housing units will be constructed in Kalutara and Rathnapura districts.

The Ministry of Public Administration, Disaster Management and Livestock Development employed M/s Yapka Construction (Private) Limited as the contractor of this project and appointed National Building Research Organisation as the Implementation Agency. As the initial step, the contractor has commenced the site clearance and construction work in 3 sites namely, Pimburawatta, Mirishena and Halwathura.

Article by Human Settlement Planning and Training Division

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Resilient Housing through Sri Lanka Defence Workmanship

Sri Lanka Army, Sri Lanka Navy and Sri Lanka Air force under the direction of the Ministry of Defence contributed its civil construction services to construct disaster resilient housing for the victims of Arnayaka landslide in 2016 (30 houses) and flood and landslide affected families of Eheliyagoda (25 houses), Kotapola (8 houses) & Morawakkanda (10 houses) in 2017.

These houses were built using funds from different private sector and INGO donors and built as per specifications of the National Building Research Organisation (NBRO).

Aranayaka Houses - Constructed by SL Defence

Kotapola Houses - Constructed by SL Defence

Eheliyagoda Houses - Constructed by SL Defence

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National Building Research Organisation || NBRO

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