Vision BIG

ASCE
SRI LANKA SECTION

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BROADLANDS HYDROPOWER PROJECT

THE STORY OF THE COVER PAGE

Name of the project
Broadlands Hydropower Project

The Employer
Ceylon Electricity Board

The Engineer
Central Engineering Consultancy Bureau

The Contractor
China National Electric Engineering Co. Ltd.

District
Kegalle and Nuwara-Eliya

Capacity
35MW

Brief description
The project scope was to construct Powerhouse, reservoir and tunnels. There are two tunnels called main tunnel and diversion tunnel. Main tunnel carries water from the reservoir to the powerhouse and the length of the tunnel is about 2.5km. The diversion tunnel is for carrying water from the Kehelgamu oya to the reservoir. Broadlands is the last project of the Laxapana complex as well as the downstream of Kelani river. This project is now completed and contributes to the national grid.

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The Editor:
Eng. Rohana Dasanayake

Articles for the next issue can be submitted by any person who are recognized as professionals in any profession. Send your articles in MS Word format to the Hon. Secretary of the Sri Lanka Section of the American Society of Civil Engineers. For further inquiries

secretaryasceslig@gmail.com

THE PRESIDENT'S MESSAGE

Eng. K.P.I.U. Dharmapala
President-(ASCE-SLS)

It is with pride and a sense of accomplishment that I send this message as President of the American Society of Civil Engineers, Sri Lanka Section (ASCE-SLS) on the occasion of the releasing of first issue of the Official News Letter, "VisionBIG".

ASCE established in 1852 and ASCE-SLS established in 2017 which is an internationally recognized professional body with a total membership exceeding 933 members. This includes members of the Student Chapter too. The Sri Lanka Section's forward march to its vision has seen unprecedented positive transformation, especially during the past year. Its facilitation of professional development of its members in participation in professional development programs such as Site visits, Seminars, public lectures etc. that supported their upward movement. I am quite confident that with the releasement of this newsletter will definitely pave the way of its members to enhance their professional knowledge with respect to emerging engineering technology.

Engineering is a nation building profession and engineers play a vital role in the rapid development processes taking place in all sectors all over the country. As engineers, ASCE-SLS members are involved in the implementation of small, medium and major infrastructure development projects in the spheres of Information Technology, Power generation, Road development and construction, Water supply and Irrigation deserve much praise and appreciation.

I appreciate the commitment and dedication of the Executive Committee of the ASCE-SLS towards the promotion and advancement of science and engineering in our country and I wish the all the best, good luck and great Success in the all-future endeavors!

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Sub-committees

- Membership committee
- Publications committee
- Education & Training committee
- Publicity & Social events committee
- Professional affairs committee

EVENTS CONDUCTED BY ASCE-SLS

1. Visit to Broadlands Hydropower Project – 28th September 2019

2. Webinar on the topic of "Provision of Water and Sanitation: Challenges and Opportunities for Population access to WASH Services in Sri Lanka – 08th September 2020

3. Webinar on the topic of "Provision of Water and Sanitation: Challenges and Opportunities for Population access to WASH Services in Sri Lanka – 08th September 2020

4. Presentation on the topic of "Is Sri Lanka immune from consequences of devastating earthquakes?" – 12th October 2021

5. Online mode lecture series celebrating the "World Environment day" – 04th to 06th June 2022

6. Presentation on the topic of "Dispute Resolution in Construction" – 09th June 2022

7. Online presentation on the topic of "Design and Construction Technologies in High Skewed Bridges – Case study with greatest Skew Bridge in CEP2, Sri Lanka" – 08th September 2022

NATURE BASED LANDSLIDE MITIGATION IN SRI LANKA – A FUTURISTIC APPROACH

By Prof. Udeni P. Nawagamuwa
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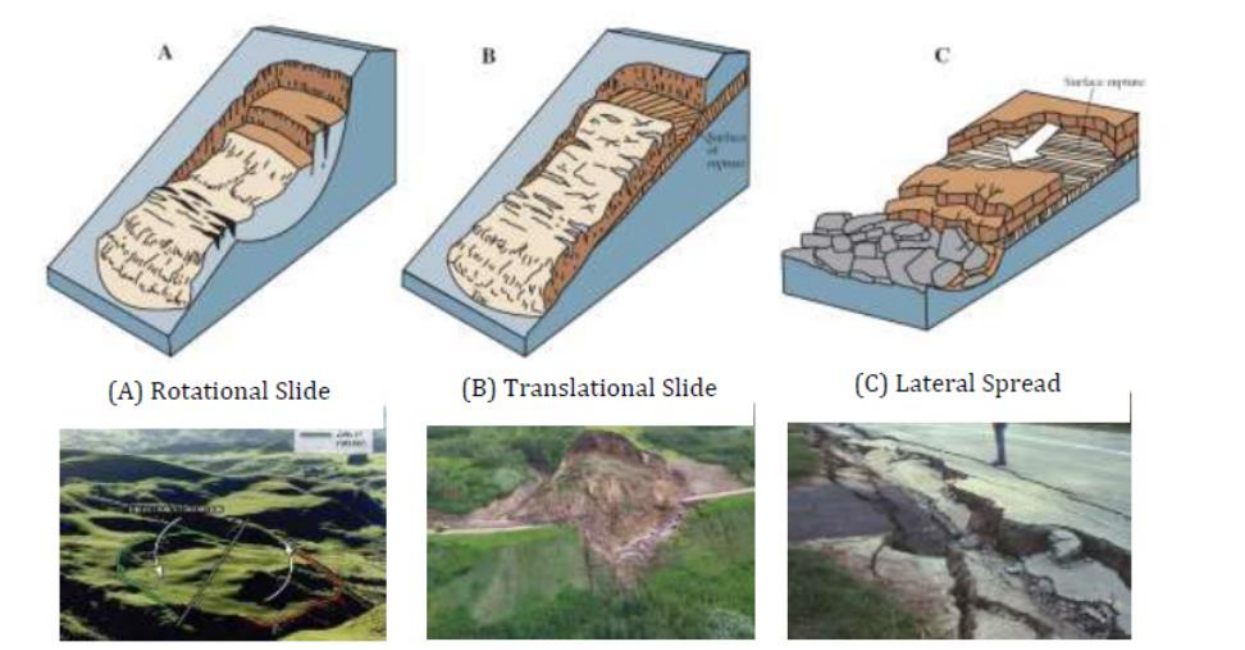
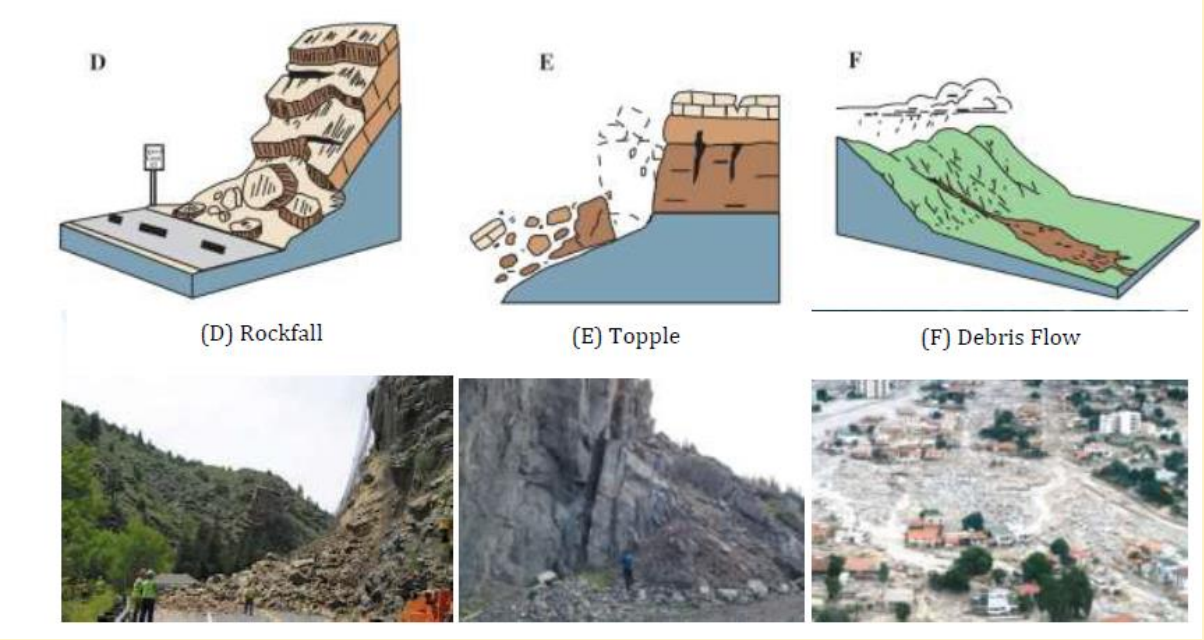
It is evident that Sri Lanka is becoming one of the hotspots for Landslides in South Asia. This article discusses the types of landslides, different mitigation methods, and Nature Based Solutions (NbS).

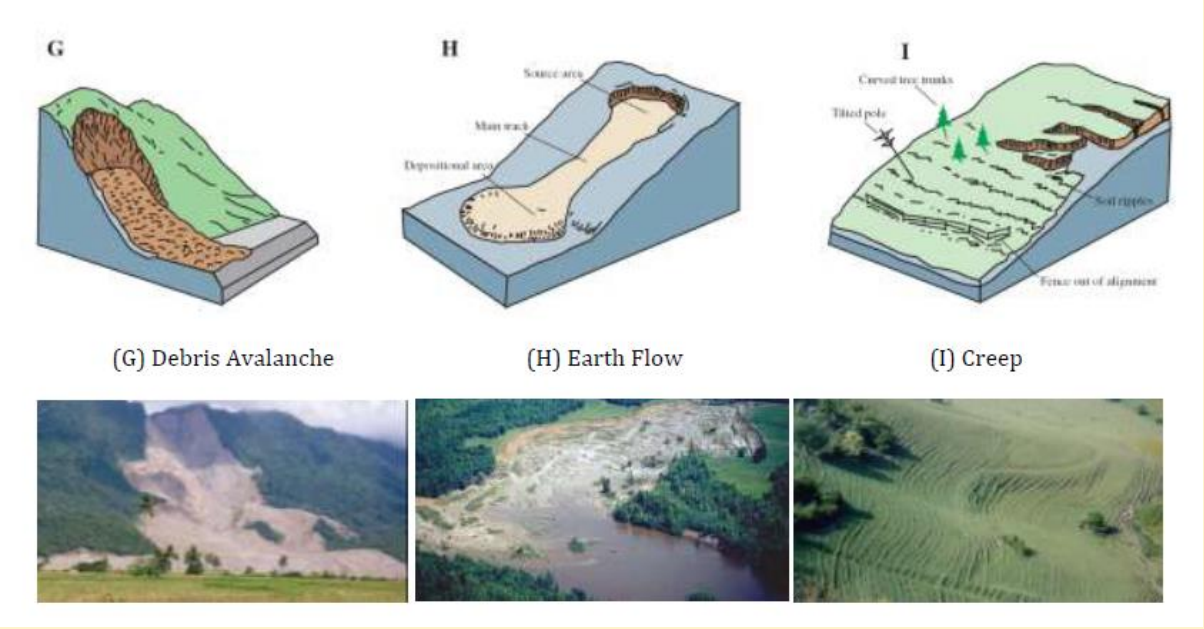
According to USGS, a landslide is defined as the movement of a mass of rock, debris, or earth down a slope under the direct influence of gravity. Landslides can be initiated due to excessive rainfall, snowmelt, changes in water level, stream erosion, changes in groundwater, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors.

Sri Lanka has faced devastating landslides mainly due to heavy rainfall but, sometimes in association with the disturbances made by humans. They are commonly a result of building roads and structures without adequate grading of slopes, poorly planned alteration of drainage patterns and disturbing old landslides.

The term "landslide" encompasses five modes of slope movement: falls, topples, slides, spreads, and flows. Figure 1 depicts those types with real cases.







Why do we need to study landslides?

According to historians, civilization commenced in river basins, and it is the same for Sri Lanka as well. Sri Lankan Kingdoms moved from Anuradhapura and Polonnaruwa - a relatively flat terrain to hilly areas. As people move into new areas of hilly or mountainous terrain, it is important to understand the nature of their potential exposure to landslide hazards, and how cities, towns, and counties can plan for land use, engineering of new construction and infrastructure which will reduce the costs of living with landslides.

Although the physical causes of many landslides cannot be removed, geologic investigations, good engineering practices, and effective enforcement of land-use management regulations can reduce landslide hazards.

It is also important to understand the science of landslides, their causes, movement characteristics, soil properties, the geology associated with them, and where they are likely to occur.

Landslide Hazard Zonation Mapping Project (LHMP) implemented by NBRO

A commendable approach in reducing the landslide disaster is the hazard zonation mapping process initiated by the National Building Research Organization (NBRO). Those maps display the distribution of the severity of landslide hazard potential in a given area. Hazard zonation mapping is based on an extensive field study and evaluation of six causative factor attributes such as geology, slope, soil overburden, hydrology, landform, and land use patterns in the area.

Maps are available in 1:50,000 scale and 1: 10,000 scale. 1:50,000 scale maps are available for Badulla, Nuwara Eliya, Kegalle, Ratnapura, Kandy, Matale, Kalutara, Galle, Matara, Monaragala districts. 1:10,000 scale maps are available for selected areas of the above districts. Some examples are shown in Figure 2 (a and b). Those maps are heavily used in infrastructure planning.

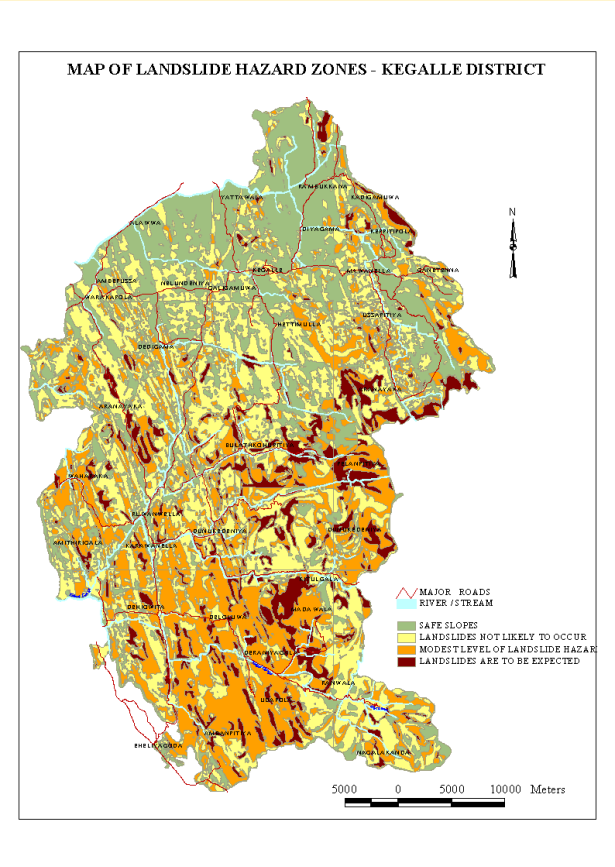


Figure 2 (a) . 1:50,000 Landslide Hazard Zonation map of Kegalle District

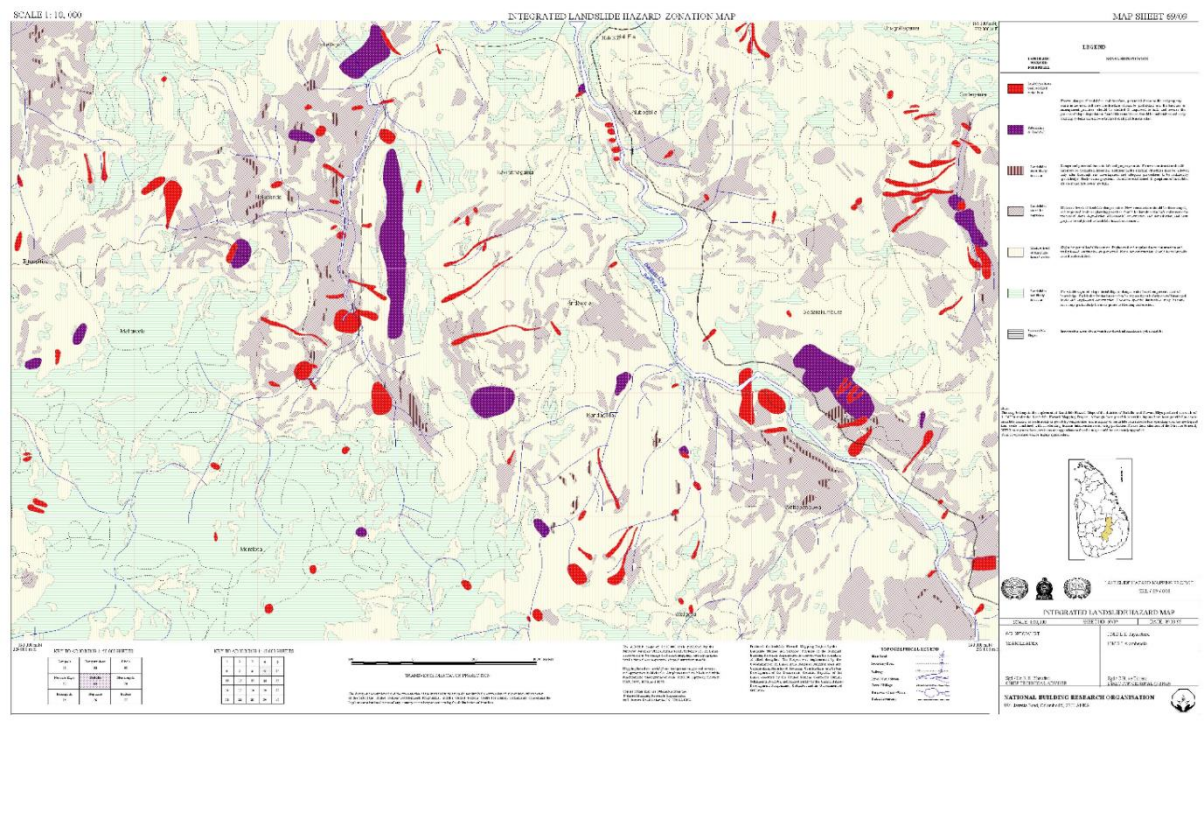


Figure 2 (b). 1:10,00 Landslide Hazard Zonation map from a map sheet in Badulla District

Different Mitigation Measures

Different terminology has been used in describing mitigation measures. Those are active and passive, hard and soft and preventive and remedial. The term "active" and "passive" stabilization measures in relation to whether the mitigation measures "actively" pursue an improvement of the stability of the slope, or they "passively" intercept the run out when movement occurs, protecting the elements at risk.

"hard" and "soft" stabilization measures are defined as; "hard" is normally used to describe structural techniques that are visually obvious, while "soft" is normally used to describe techniques that are visually less intrusive and which improve the strength or other properties of the ground, such as its drainage capability.

While "preventive" and "remedial" stabilization measures relate to their relevance to different stages of movement.

Nature-based solutions (NbS)

Interventions which make use of natural processes and ecosystem services to address hazards such as floods, erosion and landslides are referred to as NbS. Those can be complete "Green" (consisting of only ecosystem elements) or "Hybrid" (combination of ecosystem elements and conventional engineering measures).

IUCN has declared eight principles of relevance to nature-based solutions (NbS). Those are as follows.

Embrace nature conservation norms (and principles); Can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions); Are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge; Produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation; Maintain biological and cultural diversity and the ability of ecosystems to evolve over time; Are applied at a landscape scale; Recognize and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystems services; and Are an integral part of the overall design of policies, and measures or actions, designed to address specific challenges.

Benefits of NbS in stabilizing slopes

Two basic mechanisms are applicable to NbS, those are hydrological and mechanical mechanisms. Plant evapotranspiration mechanisms serve as rainfall holders by maintaining the negative pore water pressure on the ground (Greenway, 1987). The soil will maintain as an unsaturated mass with no/less pore water pressure that could create slope failures.

The higher the density of the canopy and leaf area, the greater the ability to catch rainfall (water interception) and interception reduces and delays rainfall to the soil surface (Mulyono et al., 2018).

Shear stress, transferred in the ground into tensile resistance in the roots, carries out the mechanical soil reinforcement by the roots. Root condition also has a role in holding the soil layer. A tree's roots will increase the soil shear strength via the tensile strength of its own roots and provide slope-shearing resistance during or after heavy rainfall on shallow landslides (Fan and Su, 2008).

Root-soil matrix

Roots are strong in tension, whereas soils are strong in compression but weak in tension; thus, the combined effect of soil and roots results in a reinforced soil. When shearing the soil, roots mobilize their tensile strength whereby shear stresses that develop in the soil matrix are transferred to the root fibers via interface friction along the root length (Gray and Barker, 2004) or via the tensile resistance of the roots (Ennos, 1990).

A multi criteria framework must be utilized when plants re selected for NbS applications. Those are Plant type and structural characteristics, Hydrological significance, Root strength characteristics, Ecological significance and Economic value.

Geotechnical assessment used in NbS applications

For an effective geotechnical assessment of an NbS application, some information must be essentially gathered. Those are material properties (cohesion and internal friction), Fracture density and quality, Degree of weathering of the material, Geometry of the material, Slope angle, Weight and load distribution, Water content and the phreatic surface, Type of vegetation and its density, External impulsive forces (such as vibrations due to earthquakes, change of phreatic surface due to rainfall, etc). For example, Figure 3 depicts the shear resistance for 2 types of root types.

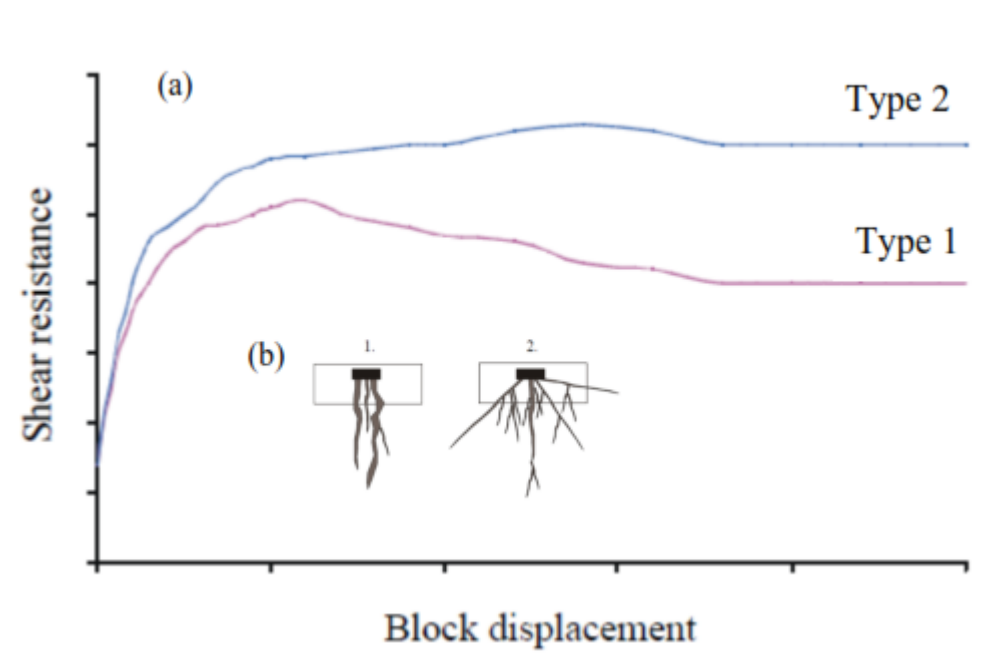


Figure 3. Shear resistance over block displacement for two types of spatial distribution of roots (modified after Docker and Hubble 2009).

Roots will provide two advantages; it will Increase the shear strength due to the anchoring effect of larger, stiffer roots and there will be an increase in shear strength due to the apparent cohesion provided by smaller roots. Figure 4 (a and b) explain the behavior of root deformation under shearing and Mohr-Coulomb envelopes of reinforced soils with vegetation and unreinforced soils.

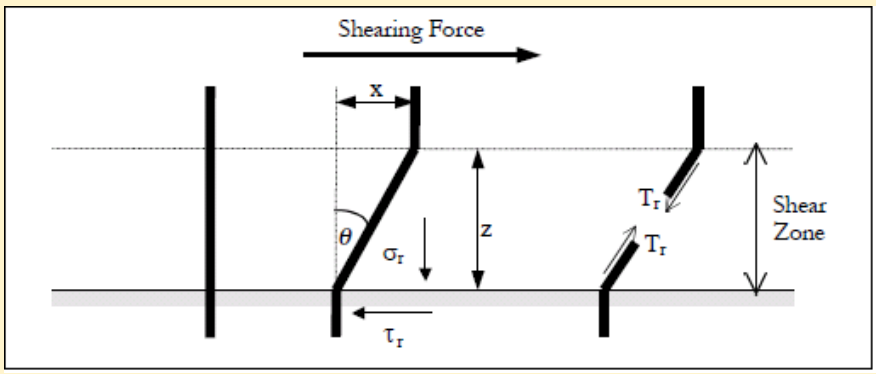


Figure 4 (a) Schematic Diagram to show root deformation under shearing (after Waldron 1981)

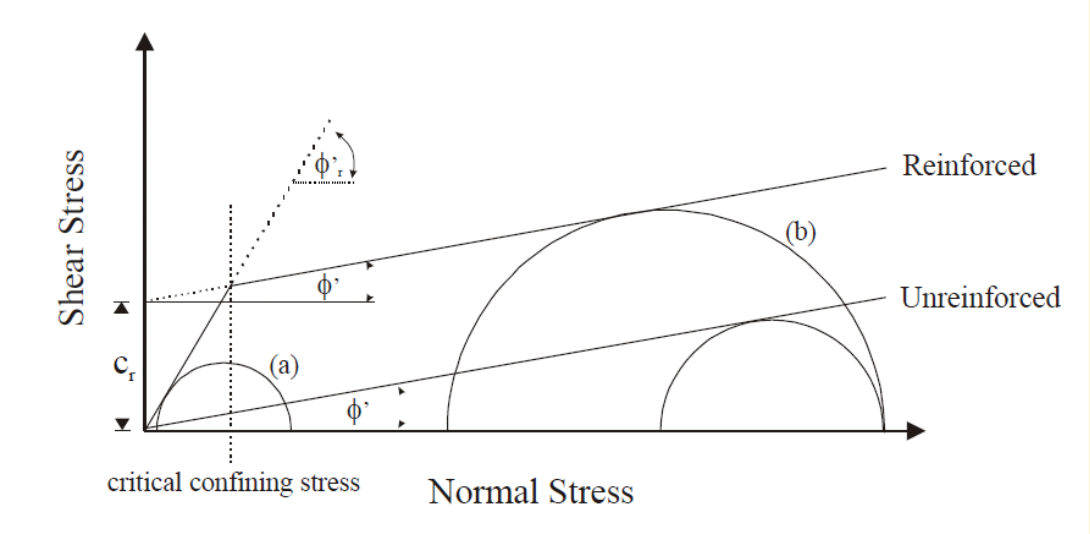


Figure 4 (b) Mohr-Coulomb envelopes for reinforced and unreinforced soils with circles describing failure by (a) slippage and, (b) reinforcement rupture

Case study – Badulusirigama

Figure 5. Layout plan of Badulusirigama pilot site and the proposed zonation map

The location shown in Figure 5 has been selected due to the availability of data and the applicability of NbS measures in the specific location due to its presence next to Uva Wellassa University in Badulla District. The analysis was conducted under three cases:

1. Slope without any mitigation measures,
2. Modified slope with subsurface drains and
3. Modified slope with an application of a hybrid system (Sub-surface drains + vegetation).

The analysis was done with SLOPE/W software and the achieved factor of safety (FoS) values are compared in Table 1.

Table 1. Comparison of FoS values calculated according to the three measures

Zone`	FoS before drainage improvement	FoS after drainage improvement	FoS after drainage improvement and applying vegetation	Percentage increase of FoS after applying the hybrid solution
01	1.001	1.180	1.464	46.3
01 (with surcharge)	1.001	-	1.760	75.8
02	0.959	1.137	1.261	31.5
03	0.913	1.140	1.367	49.7

These results clearly exhibit the advantages of using NbS measures in stabilizing slopes. Similar approaches were adopted in designing a few other unstable slopes in Ratnapura, Galle and Kandy districts. However, during these studies, the following facts were observed as challenges that must be overcome with time.

Major Challenges to NbS Application in Sri Lanka for Landslide Risk Management

Landslide risk mitigation designers do have a lack of confidence in the use of vegetation for slope stabilization. Lack of knowledge about soil bioengineering and landscaping measures to stabilize unstable slopes often limits designers from applying such solutions in landslide countermeasures is a serious concern. To make the situation worse, the government and donor community involved in landslide risk mitigation interventions have shown limited interest in allocating more resources for associated research, capacity building, and knowledge enhancement of the landslide professionals to address the capacity gaps concerning NbS application in landslide risk management.

Acknowledgement

The Author wishes to acknowledge his former students who carried out research studies related to NbS, Dr. Asiri Karunawardena and the staff members of the National Building Research Organization for providing data, Eng. Susith Aramabepola and his team at Asian Distaste Preparedness Center for coordinating this study, and the World Bank for funding.

ACOUSTIC CONSIDERATION IN AUDITORIUMS

By Eng. Priyantha Waidyasekara
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Engineer Sri Lanka Broadcasting Corporation

ABSTRACT

Effective auditorium design should address the goals of Speech, vocal performances and music. It should be a clean sound rather than a distorted or echoed (having or making a sound or sounds caused by the reflection of sound waves from a surface back to the listener) sound. Acoustics is to make the music or speech sound as good as possible. Sounds should be loud enough for the audience, including those sitting at the deep back of the auditorium. This paper focus to identify how acoustics are generally achieved in auditoriums based on the method, technics and material used.

Keywords: Sound propagation, Reverberation time, Echo, benefits of acoustics and issues in loudspeaker system

Key areas

- Requirements of the auditorium's floor area and volume for acceptable loudness in all areas of the auditorium
- Maximum reverberation characteristics that work with the auditorium to enable whatever audio purpose is required
- The requirement of evenly dispersed sound energy within the room
- Control of acoustical defects(distinct echoes, flutter echoes, picket fence echo, sound shadowing, room

INTRODUCTION

The goal for premium auditorium acoustics is equal distribution of sound for seated members of the audience regardless of their location in the auditorium. Designing an auditorium for premium sound quality starts with the basic layout of the room, ensuring that sound waves are evenly distributed throughout the space.

A common problem in auditoriums is reverberation, which occurs when sound waves bounce off surfaces and congregate. In an improper auditorium design, you may experience the speaker's voice echoing and making it difficult to understand what they were saying, you've experienced the issue of excessive reverberation.

The auditorium's design became a challenging task due to its varied varieties. In some aspects, the basic acoustical requirements of large and small halls and rooms are similar:

- The ambient noise level from both internal and external sources must be kept low.
- There must be adequate acoustic gain.
- The reverberation time must be sufficient.
- Echoes, for example, must be avoided.

SOUND PROPAGATION IN THE AUDITORIUM

The speed of sound is the distance traveled per unit of time by a sound wave as it propagates through an elastic medium. At 20 °C (68 °F), the speed of sound in air is about 343 meters per second.

The early reflection will occur after about 50 milliseconds. The reflection that occurs after the early one is of lower amplitude which marge into the reverberant sound or late reflection.

Reverberant sound builds up to an equilibrium level when the source emits a continuous sound. The level of the sound decreases at a more or less constant rate until it reaches inaudibility. The reverberation sound begins to decay immediately for impulsive sounds.

Ambient Noise Level

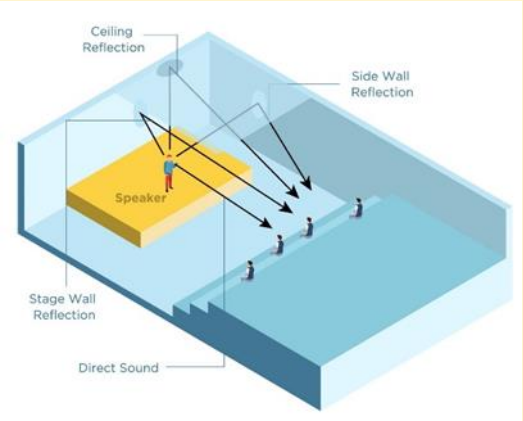
Ambient Noise Level (background noise) in metropolitan, urbanized areas typically varies from 60 to 70 dB and can be as high as 80 dB or greater; quiet suburban neighborhoods experience ambient noise levels of approximately 45-50 dB.

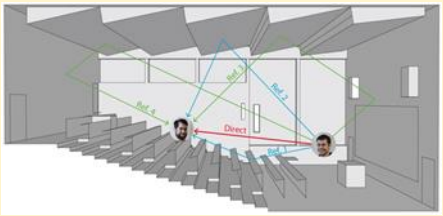
Ambient noise levels (Background noise levels) in a good auditorium will be as low as 20 dB-A. Also, there should be at least 10 dB to 20 dB between the signal and the acoustic background noise.

Sounds at or below 70 dBA are generally considered safe acoustic volumes. Any sound at or above 85 dBA is more likely to damage your hearing over time.

Auditoriums designed for orchestral music, are like concert halls with reverberation times in the 1.7 to 2.2-seconds range. It will be varied with the purpose of the application. For example, the recommended reverberation time for the typical lecture hall is 1-1.5 seconds.

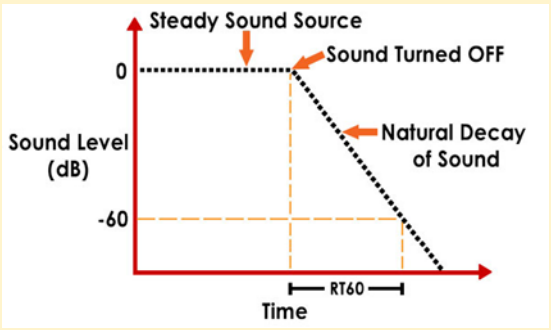
Reverberation is the continuing presence of audible sound after the production of sound has stopped. It is affected by the reflective properties of the surfaces in the hall or acoustic





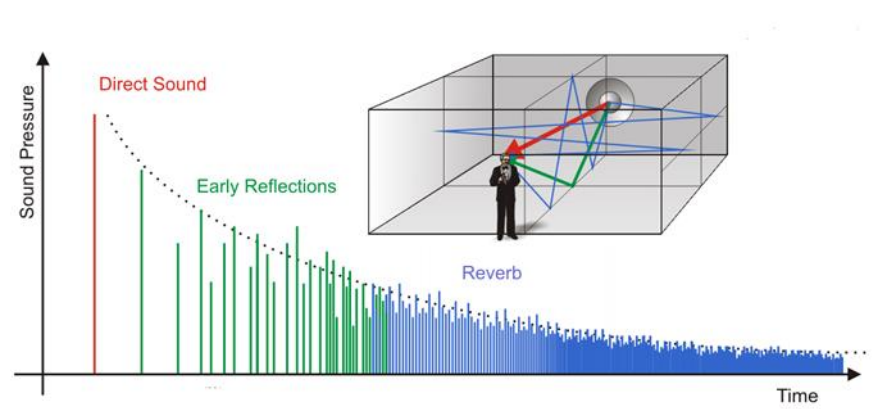
room. A reflective surface will cause the sound to die away for a long time, while an absorbance surface will cause the sound to die away quickly. Reverberation time is the length of time for the sound pressure level in a room to decrease by 60dB from its original level after the sound is stopped. It is dependent upon a few factors, the volume of the enclosure (distance), total surface area, and the absorption coefficients of the surface.

Reverberation time, or RT60, is a metric that describes the length of time taken for a sound to decay by 60 dB from its original level. Optimal reverberation times vary depending on room volume, the intended use of the space, and the frequency of transmitted sound.



An echo is caused by sound waves bouncing off a hard surface so that you hear the same sound again. Large rooms in homes can create echoes, especially if the room has mostly hard, bare surfaces, high ceilings or does not have much furniture.

Echo can be removed or reduced by treating the surfaces of the auditorium.



The focus of this paper is to explain acoustics and the requirement of room acoustics for a better level of sound. Room reverberation and echo are not limited to sound studios or auditoriums. Building acoustics were widely applied in urban buildings for a better working environment.

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LISTENING IS NOT THE SAME AS HEARING

By Eng. Shantha Senarath
GCGI(UK), MCGI(UK), FIIESL, IEng (SL), DTM (USA)

Merriam-Webster defines HEARING as the "process, function, or power of perceiving sound; specifically: the special sense by which noises and tones are received as stimuli." LISTENING, on the other hand, means "to pay attention to sound; to hear something with thoughtful attention; and to give consideration."

Real listening is an active process that has three basic steps.

- Hearing
- Understanding
- Judging

Listening is not the same as hearing. Hearing refers to the sounds that you hear, whereas listening requires more than that: it requires focus. Listening means paying attention not only to the story, but how it is told, the use of language and voice, and how the other person uses his or her body. In other words, it means being aware of both verbal and non-verbal messages. Your ability to listen effectively depends on the degree to which you perceive and understand these messages.

"The most basic and powerful way to connect to another person is to listen. Just listen. Perhaps the most important thing we ever give each other is our attention." Rachel Naomi Remen

We spend a lot of our time listening

A good listener will listen not only to what is being said, but also to what is left unsaid or only partially said.

Listening involves observing body language and noticing inconsistencies between verbal and non-verbal messages. For example, if someone tells you that they are happy with their life but through gritted teeth or with tears filling their eyes, you should consider that the verbal and non-verbal messages are in conflict, they maybe don't mean what they say. Listening requires you to concentrate and use your other senses in addition to simply hearing the words spoken.

1. Stop Talking

When somebody else is talking listen to what they are saying, do not interrupt, talk over them or finish their sentences for them. Stop, just listen. When the other person has finished talking you may need to clarify to ensure you have received their message accurately.

2. Prepare Yourself to Listen

Relax. Focus on the speaker. Put other things out of mind. The human mind is easily distracted by other thoughts – what's for lunch, what time do I need to leave to catch my train, is it going to rain

3. Put the Speaker at Ease

Help the speaker to feel free to speak. Remember their needs and concerns. Nod or use other gestures or words to encourage them to continue. Maintain eye contact but don't stare – show you are listening and understanding what is being said.

4. Remove Distractions

Focus on what is being said: don't doodle, shuffle papers, look out the window, pick your fingernails or similar. Avoid unnecessary interruptions. These behaviors disrupt the listening process and send messages to the speaker that you are bored or distracted.

5. Empathise

Try to understand the other person's point of view. Look at issues from their perspective. Let go of preconceived ideas. By having an open mind, we can more fully empathize with the speaker. If the speaker says something that you disagree with then wait and construct an argument to counter what is said but keep an open mind to the views and opinions of others.

6. Be Patient

A pause, even a long pause, does not necessarily mean that the speaker has finished. Be patient and let the speaker continue in their own time, sometimes it takes time to formulate what to say and how to say it. Never interrupt or finish a sentence for someone. Some speakers deliberately pause in order to emphasize what he says.

7. Avoid Personal Prejudice

Try to be impartial. Don't become irritated and don't let the person's habits or mannerisms distract you from what they are really saying. Everybody has a different way of speaking - some people are for example more nervous or shy than others, some have regional accents or make excessive arm movements, some people like to pace whilst talking - others like to sit still. Focus on what is being said and try to ignore styles of delivery.

8. Listen to the Tone

Volume and tone both add to what someone is saying. A good speaker will use both volume and tone to their advantage to keep an audience attentive; everybody will use pitch, tone and volume of voice in certain situations – let these help you to understand the emphasis of what is being said.

9. Listen for Ideas – Not Just Words

You need to get the whole picture, not just isolated bits and pieces. Maybe one of the most difficult aspects of listening is the ability to link together pieces of information to reveal the ideas of others. With proper concentration, letting go of distractions, and focus this becomes easier.

10. Wait and Watch for Non-Verbal Communication

Gestures, facial expressions, and eye-movements can all be important. We don't just Listen with our ears but also with our eyes – watch and pick up the additional information being transmitted via non-verbal communication.

Do not jump to conclusions about what you see and hear. You should always seek clarification to ensure that your understanding is correct.

According to a 1981 study by body language expert Albert Mehrabian, words, body language and tone of voice account for 7%, 55% and 38% of effective communication. In other words, we as human beings pay more than 90% attention to body language and tone of the voice more than the actual words.

Toastmasters Program is a popular education & leadership program available worldwide through a network of clubs, which trains its club members how to use the Words, Body Language and the Tone to make their speeches more effective to enable them to become better speakers. Also, the Toastmasters education program consists of many activities to develop the listening skills of the participants.

SUSTAINABLE SRI LANKA 2030

ACHIEVE SUSTAINABILITY THROUGH CONSTRUCTION & DEMOLITION WASTE

By Shalitha Etipola
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Sri Lanka is a country, which is now taking great strides in developing the living standards of the people in the country who suffered a 30-year long civil war. To assist with this development island nation has many ongoing construction projects and the number of projects will increase in times to come. The highly active construction industry has caused a high amount of Construction & Demolition (C&D) Waste Production in the country, which is now exceeding the bearable limit that can be managed by conventional waste management methods such as diverting the waste to landfills. As the landfill areas are now at the level of overflowing in the country, proper waste management techniques must be adopted to ensure there are minimal adverse impacts on the environmental, social & economical aspects. Sustainable development has become an important concept all around the globe; hence, Sri Lanka has also looked towards adopting sustainable features especially in the construction industry. Sustainability in waste management is one such feature that can be adopted in Sri Lanka, which can make a huge difference in the construction industry by mainly mitigating the adverse impacts on the environment. In addition, sustainable waste management techniques can go a long way in adopting sustainability to a certain development project. One way of sustainable waste management is waste recycling and the application of recycling materials.

C&D waste recycling is the way forward in terms of sustainable waste management in the construction industry. Construction waste management center (COWAM) in Galle is the first and only C&D waste recycling plant in Sri Lanka, which was implemented as a solution for the debris left from the tsunami 2004. This was a great initiative taken in the aspect of sustainable C&D waste management. Main materials produced in a recycling plant such as this are Construction & Demolition Recycled Aggregates (CDRA) and Recycled Concrete Aggregates (RCA). CDRA contains different crushed construction materials such as bricks, ceramics, concrete blocks, mortar, reinforced concrete, steel, plastic, asbestos, wood, etc. RCA predominantly contains crushed concrete. Even though Sri Lanka has not yet looked towards Recycled Aggregates (RA) as a substitution for conventional aggregates, Application of RA has gained popularity in other countries mainly due to the positive impact made regarding environmental considerations. RA production generally undertakes, collection of C&D waste, separation, crushing and screening processes. At this time RA, have to compete with natural aggregates in quality, quantity and cost aspects. Many foreign studies have evaluated the quality aspect of RA in various fields of applicability and gained positive results. With new buildings coming up and old buildings being demolished, waste generated in construction phases and natural disasters

occurred generates enough C&D waste to provide recycling material to meet the demand in terms of quantity. The increased cost of natural materials and costs associated with C&D waste management also makes a strong point in the application of RA.

Now recycled aggregates produced in the COWAM center are mainly used as a fill material. However, these materials have the potential to be used for many different construction purposes such as pavement construction (Base or Sub-Base) or in concrete production. Lack of knowledge regarding the character and strength properties of RA in Sri Lanka is the main reason for the lack of use of this material in the construction industry. Foreign countries are already using RA for concrete production, pavement construction, as a filling material, etc. To achieve a certain level of sustainability in the coming years and to reach the goal of being a sustainable nation in 2030 C&D waste recycling and using the recycled material for construction purposes would be one way of making progress. For this to happen, intensive studies need to be carried out to evaluate the material properties of recycled aggregates. From the results of these evaluations, the strengths and weaknesses of these materials must be identified, and a proper guideline must be put in place to ensure the proper application of RA in the construction industry. Cost-effectiveness of the material is another area to consider, as this would be a major factor to influence the personnel in the construction field to use RA. In this regard, the implementation of recycling plants provincially would help to reduce the transport costs associated with RA production. On-site C&D waste separation would also help the cause in further reducing recycled aggregate production costs. Furthermore, recycling can be done on-site which would be more cost-effective for the contractors if properly managed and it will add more value to the construction projects in the aspect of environmental friendliness and sustainability.

EXTERNAL STAKEHOLDER ASSESSMENT IN CONSTRUCTION PROJECTS: CLASSIFICATION, PRIORITIZATION AND ASSESSING THE ENGAGEMENT LEVEL

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1. INTRODUCTION

Management of external stakeholders is an important task to be carried out during a construction project as they are a major source of uncertainty. This study consists with major four objectives. To identify and rank the most common factors affecting the stakeholder management process in construction project; To identify external stakeholders and assess the stakeholder attributes within Sri Lankan construction Industry; To identify the stakeholders' engagement level based on their influence; To suggest solutions to minimize negative influence of external stake holders in the Sri Lankan construction Industry. External stakeholders are secondary stakeholders who are affected by the construction project either positively or negatively. The basic problem associated with external stakeholders is that if a facility is to be built some external stakeholder will be negatively affected by that facility or by the implementation of the construction project progress. Therefore the challenge is how facing negative impacts.

2. LITERATURE REVIEW

Stakeholder is "any group/individual who can affect or is affected by the achievement of the project objectives" (Freeman, 1984). In construction, there has been a strong emphasis on the internal stakeholder relationship while the external stakeholder relationships to some extent have been considered a task for public officials via the rules and legislation that concern facility development (Atkin & Skitmore, 2008). The basics are identification of stakeholders, gathering details, identification of mission, determining strengths and weaknesses, identification of stakeholder strategy, prediction of stakeholder behaviour, and implementing stakeholder management strategy. Identifying stakeholder; prioritizing, visualizing; engaging stakeholders, and monitoring effectiveness of communication when managing stakeholders are also important attempts (Walker, et al., 2008). Identification of stakeholder consists both internal and external stakeholders that are involved in the project and also affected stakeholders by the project (Karlsen, 2002). The management team need to identify stakeholder by the guidelines or by their role as clients, contactors and consultants (Ye, et al., 2009).

3. METHODOLOGY

Non-probability sampling techniques were used in this study where target population involves in large scale Southern Highway Project by RDA and Project by National Water

Supply and Drainage Board (NWSDB) (N=50). A structured questionnaire was used in here and data are collected in a general manner from sample of the population. The general manner makes way to perform statistical analysis of the data by using SPSS statistical software and Microsoft Office Excel. The survey was carried out between the months of February– March 2021)

3.1 Relative Importance Index (RII)

The contribution of each of the factors regarding the effectiveness in managing the external stakeholders was examined by use of Relative Importance Index (RII).

$$RII = \frac{\sum W}{AN}$$

Where,

W = Weightage given to each factor

A = Highest weight in Likert scale (i.e., 5 in this case)

N = the total number of respondents

3.2 Prioritizing stakeholders

Olander (2007) adapt this approach to determine whom the most important stakeholder in the construction project.

Impact level = Power + Proximity + Legitimacy + Urgency + Knowledge

Impact index = √ (vested interest * impact level) * 25

Influence index = Impact index * Attitude

3.3 Classification of the stakeholder

The classification of construction stakeholder is based on the impact / probability matrix approach which is adapted from Olander (2007).

Probability of impact = Vested interest

4. RESULTS AND DISCUSSION

4.1 Respondents' profile

Table 1 shows the percentage involvements of of the institutions, job titles and years of experience.

Table 1: Respondents' profile

General information	Percentage
Institution	
RDA - Southern Highway	42%
NWSDB	58%
Job title for respondent	
Project Engineer	68%
Engineer Assistant	32%
Years of experience	
Less than 5 years	4%
5 – less than 10 years	34%
10 – less than 15 years	22%
More than 15 years	38%

4.2 Ranking the factors affecting the stakeholder management process

When considering the sixteen identified factors affecting for stakeholder management, "identifying external stakeholders" with RII (88.00%) was ranked in the top of the factors that affect stakeholder management process and "Evaluate the stakeholder power" with RII (66.40%) was ranked in the last position.

4.3 Stakeholder Assessment

4.3.1 Stakeholder prioritization

As can be seen in Figure 1, the RDA and Survey Department ranked on top; meaning that these stakeholders are likely having the most influence and should therefore receive the project manager's most attention. Community representatives are thought to impact poorly on construction projects. However, they were

to highlight a particular issue with a decision, it is likely that serious consideration would be given to refining the decision made as they are highly associated end users.

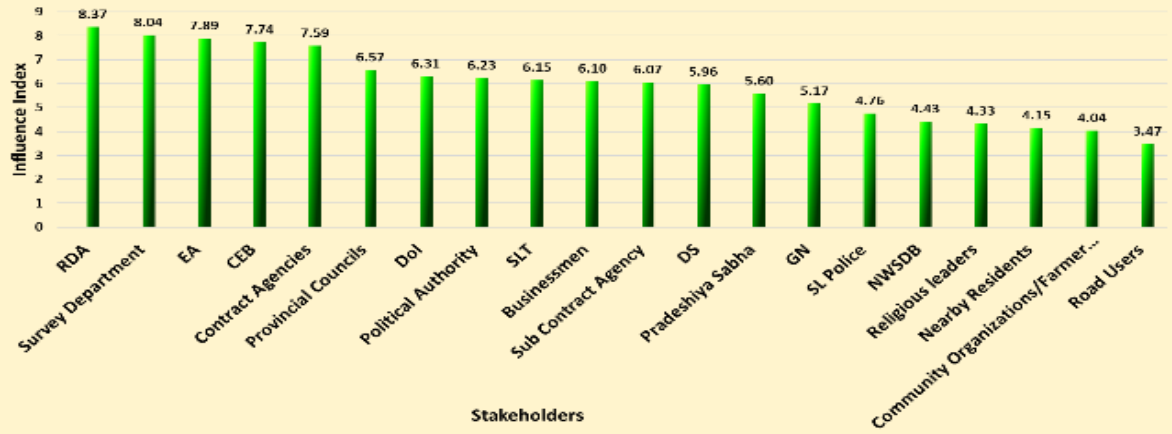

Figure 1: Summary of stakeholder influence index

4.3.2 Classification of the stakeholders and assessing the engagement level

Figure 2 shows the classification of stakeholder ranks based on their level of impact upon vested interest. The community representatives which ranked lowest are included in keep informed group (Involve engagement) and rest of the stakeholders are considered as key players (Collaborative engagement). Key stakeholders (collaborators) have a high probability of impact and level of impact to project success. As long as the interests of involved group is achieved, they are remained satisfied and retain passive.

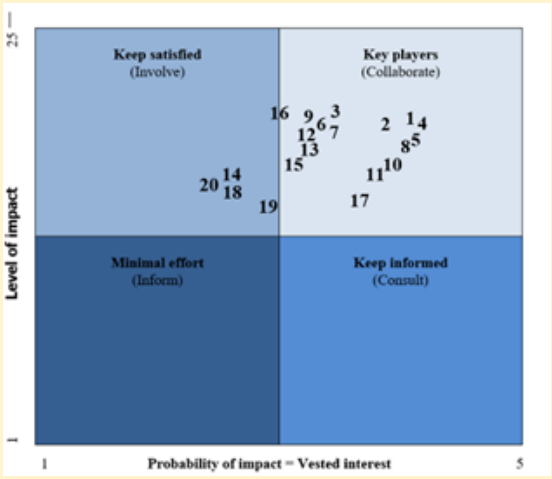

Figure 2: Probability Impact Matrix

5. CONCLUSIONS

Based on the above results, the following suggestions are deduced to minimize negative influence of external stakeholders in the Sri Lankan construction Industry. Recruit a project manager based on his competencies to lead the management; Provide training on communication and negotiation with stakeholders; Work closely with the 'key players'; Should not neglect the effect of 'involved' stakeholders; Adopt the stakeholder assessment strategies within projects.

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