

# Landslide mitigation: a novel architectural and engineering intervention.

U.K.D.C. Dilshan

*Department of Architecture, University of Moratuwa, Sri Lanka*

A.A. Hettiarachchi

*Department of Architecture, University of Moratuwa, Sri Lanka*

**ABSTRACT:** Landslides have been recognized as an increasing catastrophic environmental hazard in Sri Lanka, which is caused mainly due to unplanned human interventions. The current paper draws attention to a hypothetical experimental resettlement project taken up as an academic exercise within a landslide mitigation area namely, Peradeniya town. The novelty of the design is the careful marriage between the engineering and architectural solutions to mitigate the hazard while effectively utilizing the same as a potential to upgrade its existing townscape and socio-economic and spatial conditions. Necessity in reinforcing the ground is identified as the principle engineering feature of mitigation. Removal of the top soil layer, which is highly susceptible to erosion, is suggested, reaching the more stable and safe layer appropriate for construction. The space created by removal of soil is to be carefully used for the architectural intervention where the commercial activities taking place within the river reservation are to be resettled. This hypothetical new intervention provides a safe and sound landslide resilient urban re-settlement while creating an attractive and functionally supportive commercial and recreational centre enhancing their socio economic standards.

## 1 INTRODUCTION

Landslides have been recognized as a frequently increasing catastrophic environmental hazard in the recent past, causing damage to innocent lives, property and livestock in Sri Lanka. Investigations carried out by National Building Research Organization (NBRO) reveals that, apart from natural forces, landslide susceptibility is caused mainly due to unplanned human interventions, explicitly haphazard developments and the use of inappropriate building construction techniques (Bandara 2005). In view of this, all the decision makers including architects, engineers and town planners have a greater responsibility in coming up with innovative design solutions ensuring a safer built environment.

The current paper draws attention to a hypothetical experimental resettlement project, taken up as an academic exercise, to be executed in a landslide mitigation area in the hill country; Peradeniya. The main feature of the design worth exploring is the careful fusion between the engineering and architectural intervention to create a safe and sound landslide resilient urban re-settlement centre with socio-economic value while rearranging the physical setting of the town into an attractive gateway to the hill country.

## 2 PROJECT BACKGROUND

It is quite evident that landslides are more common natural phenomena in most parts of the world. In Sri Lankan context, this is most noted in the central province especially during the monsoon season. Peradeniya, which could be identified as a key town in the central mountain system of Sri Lanka, is a small town centre situated 6 km away from the renowned historic city of Kandy, edged by the Mahaveli River on the east and Peradeniya Mountain on the west. Peradeniya town itself holds its dignity with its educational, social and economic contribution to the country. It also is a location prone to landslide as the natural slope has been modified to construct the Colombo Kandy (A1) main road and is reported to have been critically affected by landslides during the past decades. Peradeniya has a lot of commercial and residential activities located within the reservation area of the road and river and these have been identified as to be resettled due to the risk of landslide.

In the process of landslide mitigation, the general and accepted practice would be to resettle the people of identified danger zones in safer areas. This resettlement, occurring within a community or a subsystem of a community, brings various impacts and imbalances to the society. The people to undergo the resettlement process are prone to various mental calamities since they are challenged to adapt to the newly created environment. This becomes more critical in the case of elderly people since they try in maintaining their dignity attached

to the place where they were born, grown up and hope to die as well. This phenomenon is more common within the countries of the Asian region. On the other hand, limited facilities can be seen as a main characteristic of most of the resettlement areas, mainly due to quick reactions made by the authorities to cope up with the emergency situation. This makes the affected people even more stressed out. Metaphorically, the current resettlement process could be portrayed as rending a deep rooted tree from a rain forest and replanting it in a completely different locality.

It is an obvious fact that a government should save the lives of citizens, but with a minimum impact to their lives. At this juncture, this hypothetical design looks into an architectural and engineering solution which is capable of mitigating the risk of landslides while keeping the settlement unchanged and in the same place where it belonged to.

### 2.1 The nature of landslides in Peradeniya.



Fig 1: Proposed Site at Peradeniya, Kandy  
Source: Human Settlements Division: NBRO

A landslide could occur in various forms. Among them, the most common phenomenon is sliding down of soil and rock from hill tops to the bases, devastating the vegetation and property and lives.

A landslide can mean differently depending on the circumstances and conditions. However, generally speaking, the movement of a considerable mass of rock and / or soil along with the vegetation

and structures thereon from a higher to a lower elevation under the influence of gravity may be termed as a landslide (Bandara, 2005). According to the investigations done by the author, the situation in Peradeniya is different since most of the landslides occur in another form; explicitly rupture



Fig 2: Land slide risk at site; the view captured from the bridge towards kandy crossing Mahaweli river . Source: Human Settlements Division: NBRO

of soil layers or soil banks. The 2009 landslide occurring in this form had devastated almost all parts of the town. This type of landslide occurs mainly due to unplanned human interventions. Usually, people excavate soil parts from the sloping parts of the hill for their construction purposes. When this activity becomes more frequent, the slope becomes more and more steeper. This, together with the vibration of vehicles makes soil layers to be loosened and the hill to become more landslide prone.

The development of Peradeniya is restricted due to its topographical limitations. According to the studies conducted by NBRO (2008), the town has been developed to a linear form along the main artery due to lack of space for expansion. Main reasons being the Mahaweli River is at the eastern bank and Peradeniya mountain range at western part of the town acting as physical barriers. Due to the ever growing demand for land, humans spontaneously tend to excavate the hill to execute constructions, making the area more landslides prone.

Peradeniya is distinctively located at the intersection of two main arteries of Sri Lanka; (A1) Colombo-Kandy road and (A5) road leading to Gampola /Nuwara Eliya, thus has a greater potential to be developed as a main economic and recreational center, contributing to the economy of the country. The number of tourist destinations of utmost historic value located in close proximity adds on to the above. Therefore, the

architectural intervention should be with a focus on a place which helps the emergence of new economic and social activities for the benefit of dwellers and commuters while preserving the spirit of the old Peradeniya town.

### 3 ENGINEERING INTERVENTION

Removing the entrenched *ōfearō* of people regarding a potential future landslide was identified as a major challenge of the design. Therefore, the project at its onset attempted in addressing the civil engineering solution. As mentioned above, the top soil layer of sloping parts of the hill is unstable, making it inappropriate for construction. Below this slide prone soil layer would be the hard rock, which is more stable, safe and suitable for construction. Therefore, reinforcing the ground in a structurally safe and sound manner is identified as the principle engineering feature of mitigation. In doing so, it is decided to remove the top soil layer which is highly susceptible to erosion and the top layer of granite (nice layer of the rock), reaching the under lying hard rock.

The clearance of top soil layer is recommended to be done in the form of steps sloping down towards the Mahaveli River, practically similar to *ōhalmalu kramayaō*; the traditional Sinhalese system of paddy cultivation specifically found in the hill country villages. To support better storm water disposal, drip ledges are to be created similar to the function of *ōkataaram*” found in ancient cave temples enabling the storm water to be drained naturally. The base or toe of the hill, specifically the river bank area, is to be reinforced by a retaining wall constructed with the use of large rock debris surfaced while removing the *ōnice layerō* of the rock.

The gap between the earth profile and the wall is to be filled with soil which is removed while clearing the top layer. Transcending beyond the topographical limitations for development the above proposed modifications, significantly the stepped land plots, will provide arena for safer constructions on the sloping terrain.

### 4 ARCHITECTURAL INTERVENTION

The space created by removal of soil is to be carefully integrated for the architectural intervention. The removed granite is to be re-used for construction of the new building and the soil is to be utilized for landscaping.

#### 4.1 Resettling commercial activities

This building is to be used to resettle the commercial activities taking place within the river reserva-

tion while providing space for more activities with economic value in different layers. For instance, the top most level of the proposed building will cater to high-end shopping as catalyst for tourist attraction.

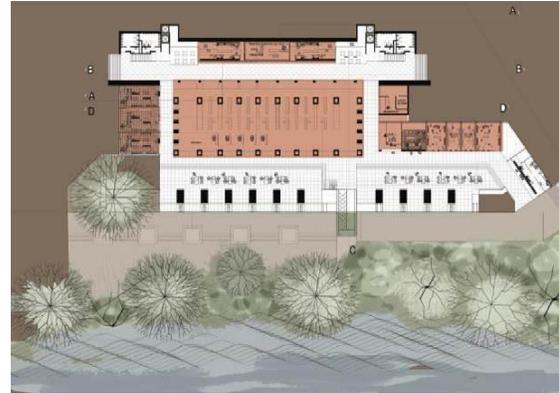


Fig 3: Proposed plan (Basement level).

Source: Author

#### 4.2 The design of a bridge.

The existing main road which is at high risk, lying on the top soil layer is to be removed and re-constructed in the form of a bridge linking both sides of the main road. The design of this bridge becomes a crucial factor of the whole architectural intervention. The space created below the bridge is to be utilized meaningfully for commercial purposes; shops, supermarkets...etc. The supermarket areas to be placed under proposed road will be lit by direct sun light taken down with the aid of sun-tunnels. These sun-tunnels are dual purpose as they are to be used as hand rails in the design.

The link underneath the bridge will increase permeability via providing better access to the proposed waterfront recreational development of the adjoining Mahaweli River as the presence of the river was not felt to the passerby due to the linear commercial development along the river bank.



Fig 4: Section A-A.

Source: Author

#### 4.3 Depicting the character of a gateway to the citadel.

Peradeniya, due to its prime location demands to be an entrance to the ancient historical city of Kandy. The current physical character of the town lacks such an image and therefore the bridge design is to be more decisive as it is to depict the character of the Peradeniya town as a gateway to the citadel.

Therefore, the architectural character is to be enhanced by incorporating arches in to the bridge, which is a significant feature of Kandyan architecture. This detail further is intended to make the bridge design not being read as a typical bridge.



Fig 5: Section C-C  
Source: Author

#### 4.4 Pavement to be relocated within the building premises.

Even though the road front area of Peradeniya town holds maximum potential for commercial activities, such activities are being restricted only to one side of the road in the current situation due to topographical restrictions. On the other hand, the characteristic road side boutiques help the passers-by; commuters and long distance travelers to take a rest with some refreshments, which is further enriched with the natural beauty of the area, significantly contributing to the economic growth of the urban centre. However, these potential visitors are being restricted and discouraged due to the in availability of proper parking facilities. Addressing this, the existing pavement area is to be relocated within the building premises where new vendor shops are to be introduced by the sides of the pavement within the building, creating an active shopping experience. The stepped formation of the design will expand the buildable road side area to incorporate commercial activities three times more than the prevailing situation, making the project more economically viable.

#### 4.5 A sustainable approach

Bricks are being used for the construction instead of concrete to regulate the temperature in a more eco-sensitive manner. This is to further allow the lower parts of the building to regulate their thermal requirements without the usage of air conditioners. Thus, the whole process of intervention explained this far is to be sustainable in terms of both economic and environmental aspects.

### 5 CONCLUSION

To recapitulate, this hypothetical new intervention attempts to provide a risk free environment to the re-settlers while creating an attractive and functionally supportive commercial and recreational centre enhancing their socio economic standards.

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