RETAINING WALL WITH SHELVES ALONG THE HILL OF LATERITIC SOIL FORMATION (A CASE STUDY)

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ABSTRACT: Hill slopes and cuttings which are stable under normal climate and weather conditions undergo movements and failures due to weathering along joints and other discontinuities in rocks, changes in drainage conditions, erosion and surface excavations, earthquakes and other causes. Surface soil and rocks over lying *in-situ* rock often undergo creep movements, and under extreme hydro-meteorological conditions result in debris slides and avalanches. Any cuttings and excavations of hill slopes are often require protection works. It is essential to ensure stability of such cuttings to have adequate safety of the buildings. The soil type in the region of Ratnagiri district in Maharashtra comprises of lateritic soil. The hills are formed by boulder mixed lateritic soil and jointed basalt rock. These rocks are porous in nature, and in rainfall periods lead to water seepage into the underlying clay soil. This increases the density of the rocks and decreases their hold in the soil base, which becomes soft due to water absorption, resulting in boulder falling and soil slippage from slopes, cuttings, etc. This boulder falling results to various accidents, traffic disruption, loss of property and life. A (G+3) Ganpatipule Devsthan building *'Bhaktanivas'* is recently constructed in Ganapatipule, Ratnagiri district, Konkan area of Maharashtra by creating a ground plot by cutting a hill, exposing about 13 meter high slope. The cut hill contains the lateritic soil formation. The rock in the hill around the building is soft, porous and loose in nature. There are chances of slipping of the soil and falling of boulders in future which may damage the building. Therefore, a 12 meter high RCC retaining wall with two shelves is proposed around the back side of the building. Accordingly the construction is undertaken and in progress for protecting the toe of the slope and protect the building from falling soil and boulder portion of the hill around. This paper includes the information about analysis of the proposed wall and also the construction procedure adopting.

Keywords: Lateritic Soil, Retaining Wall, Shelves, 'Bhaktanivas'

INTRODUCTION

Hill slopes and cuttings which are stable under normal climate and weather conditions undergo movements and failures due to weathering along joints and other discontinuities in rocks, changes in drainage conditions, erosion and surface excavations, earthquakes and other causes. Surface soil and rocks over lying *in-situ* rock often undergo creep movements, and under extreme hydro-meteorological conditions result in debris slides and avalanches. Any cuttings and excavations of hill slopes are often require protection works. It is essential to ensure stability of such cuttings to have adequate safety of the buildings.[2] The soil type in the region of Ratnagiri district in Maharashtra comprises of lateritic soil. The hills are formed by boulder mixed lateritic soil and jointed basalt rock. These rocks are porous in nature, and in rainfall periods lead to water seepage into the underlying clay soil. This increases the density of the rocks and decreases their hold in the soil base, which becomes soft due to water absorption, resulting in boulder falling and soil slippage from slopes, cuttings, etc. This boulder falling results to various accidents, traffic disruption, loss of property and life.

A (G+3) storied "Bhaktnivas" building was constructed in Ganpatipule village. For this purpose, a plot was created by cutting back a lateritic hill. The cutting had maximum height of about 13 m on the South side of the building for about 20 m length. The building is surrounded by hill of varying height.

The height of the hill on the East and West sides of the building varying from 2 m to about 5 m and the marginal distances are also kept sufficient. Therefore the chances of damages of building due to land slides or falling debris from that side are almost nil. Due to less availability of plot, insufficient marginal distances are kept to the

south/back side of the building and there, the height of hill also increased up to about 13 m. There are chances of sudden collapse and slide of the portion of the hill side during heavy monsoon season towards the building. This slide may destroy the building constructed.

Safety of building from landslide and falling debris was the issue under discussion. To safeguard the safety of building from these hazards, different alternatives were studied and decided to construct the retaining wall.

Various alternatives of different types of retaining wall are studied based on study of the soil properties, geometry of the cut and behaviour of typical lateritic soils and a wall with two shelves is proposed and accordingly the construction is under progress.

Some of the portions of the hill face is protected by brick masonry work which is of less height and about 55 m long RCC retaining wall with two shelves is under construction with varying height maximum of 12.7 m of 20 m length.

The site plan of the building and the photograph of the part of the retaining wall under construction around the building are as shown in fig. 1 and fig. 2. Red line indicates the location of retaining wall.

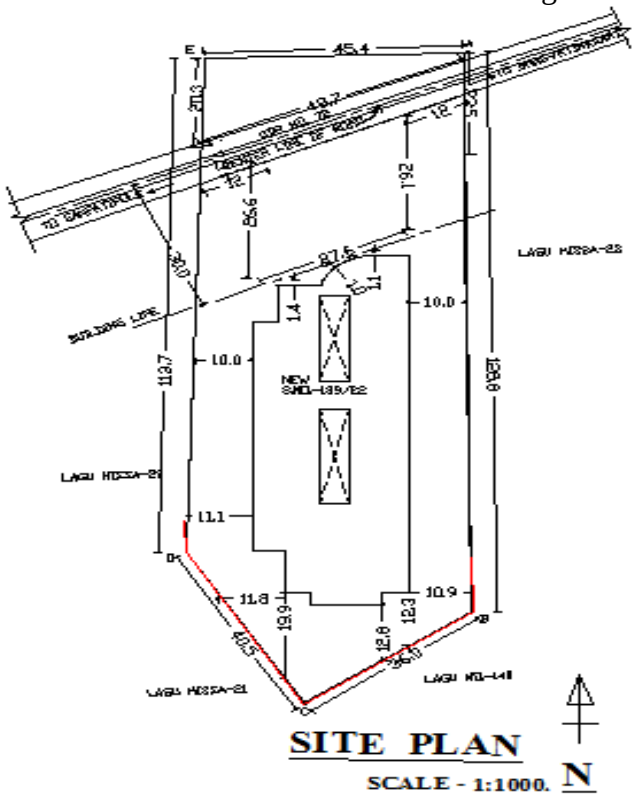

Fig. 1 Site plan of "Bhaktnivas" Building

Fig. 2 Retaining wall under construction

SITE GEOLOGY AND SOIL PROPERTIES AT THE SITE

Hill slopes and cuttings which are stable under normal climate and weather conditions undergo movements and failures due to weathering along joints and other discontinuities in rocks, changes in drainage conditions, erosion and surface excavations, earthquakes and other causes. Surface soil and rocks over lying *in-situ* rock often undergo creep movements, and under extreme hydro-meteorological conditions result in debris slides and avalanches. Any cuttings and excavations of hill slopes are often require protection works. It is essential to ensure stability of such cuttings to have adequate safety of the buildings.[1]

The soil type at the site comprises of lateritic soil. The hill is formed by boulder mixed lateritic soil. The rock found to be porous in nature, and in rainfall periods lead to water seepage into the underlying clay soil. This increases the density of the rocks and decreases their hold in the soil base, which becomes soft due to water absorption, resulting in boulder falling and soil slippage from slopes, cuttings, etc. This boulder falling results to damage of *"BhaktNiwas"* building.

During the soil investigation the disturbed soil samples are collected from site and are tested for grain size distribution. Few block samples were

also cut out from the exposed faces and tested for Density, NMC, Atterberg limits, strength, etc. as stated in Table 1.

Table 1 Soil Properties

Property	Values
Sp. Gravity	2.56
Maximum Dry Density (Kg/m^3)	2000
% Liquid Limit	44.6
% Plastic Limit	28.2
Plasticity Index	16.4
Φ Deg.	30^0
Compressive strength, (N/mm^2)	11.30
water absorption capacity	18.61%

These soil properties are checked in the laboratory and used for the analysis and design of the retaining wall.

ANALYSIS OF RETAINING WALL

Following analysis has been carried out for the proposed retaining wall by using Excel program. The obtained results are stated.

Table 2 Analysis of Retaining Wall

Retaining Wall with Two Shelves		
Total Height of Wall (H) (m)		13.5
Height of Stem (H) (m)		12.7
Thickness of Base Slab		0.8
Width of Base Slab (0.4h To 0.6h) (m)	0.38	5.13
Top Thickness of Stem(m)		0.3
Base Thickness of Stem (m)		1.2
Width of toe (0.2b To 0.4b)	0.43	2.20
Width of Heel (m)		1.72
Depth of Base of Footing (m)		1.5
Width of Shelf 1 (Upper Shelf) (m)		0.6
Width of Shelf 2 (Lower Shelf) (m)		1.2
Thickness of Shelf 1 (Upper Shelf) (m)		0.3
Thickness of Shelf 2 (Lower Shelf) (m)		0.5
Distance of Top To 1st Shelf (m)		4.23
Distance Between 1st And 2nd Shelf (m)		4.23
Distance of 2nd Stem From Base Slab (m)		4.23
Density of Concrete (N/m^3)		25000
Density of Soil (N/m^3)		20000
Angle of Internal Friction Φ		30^0
Ka		0.333333

Load Due To	Laod (N)	Distance From A (m)	Moments About A (N-m)
Rectangular	95250	3.256	310124.47

Portion (W)			5
Triangular Portion (W1)	142875	2.80	400892.963
Base Slab (W2)	102600	2.565	263169
1st Shelf (Wl1)	4500	2.3	10350
2nd Shelf (Wl2)	15000	2.6	39000
Backfill Rectangular Portion (Wb)	422321.40	4.268	2547546
Total	∑V = 782546.4		∑M1 = 2825983.0
Earth Pressure Above Shelf 1	59737	10.78	643832.51
Earth Pressure in Shelf 1 To Shelf 2	59737	6.56	391941.33
Earth Pressure in Shelf 2 To Base Slab	84448	2.127	179686.90
Total	∑H = 203922		∑M2 = 1215460.75
Z- (m)		2.06	
Eccentricity (E) (m)	Must be less than 0.9	0.50	
$P_{Max.}$ (N/m^2)		242989	
P_{min} (N/m^2)		62097.28	
F.S. Against Overturnig	Must be Greater Than 2	2.32	
F.S. Against Sliding	Must be Greater Than 1.5	1.73	

The obtained moments due to various forces are as shown in Table 3.

Table 3 Moments obtained due to various forces

Moment at	Clockwise (Shelf) Moment (N–m)	Anticlock wise Moment (N–m)	Net Moment (N–m) (Anticlock wise)
X	16578	84230	67652
Y	195686	421147	225461
Z	544759	1163693	618934

The retaining wall with two shelves and the pressure distribution diagram is as shown in Fig. 3.

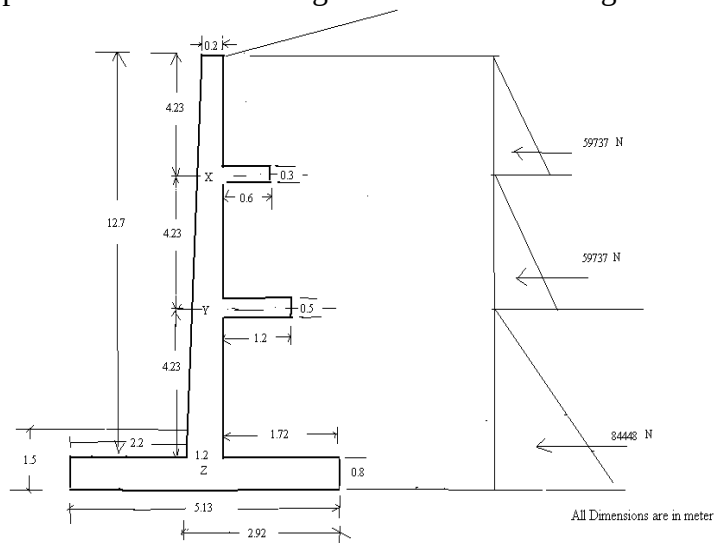

Fig. 3 Retaining wall under construction

CONCLUSIONS

Measures for long term stability of the hill slope is considered while proposing the type of retaining wall based on Properties of Lateritic soil present at the site, Possibility of slippage of boulders and landslides, Construction facilities at site and the budget available to complete the work of retaining wall. A new type of retaining wall with two relief shelves is suggested which found to be quite economical.

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