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Analysis and Design of Retaining-Wall with Shelf for Hire Medicalquarters Campus Located At Dhule

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ABSTRACT: This report consists of analysis and design of cantilever retaining wall with relieving platform. It also shows comparative study such as cost, economy, bending moment, stability against overturning & sliding between both the retaining wall. The comparative study is carried out along with the cost and optimum or least cost estimate is chosen as the best option. In this report, it is also shown that the relieving platform retaining wall is economical, more stable than simple cantilever retaining wall and it also relives the bending moment of heel portion. Also the dynamic effects of the seismic motion response are carried out on both wall and analysis is being compared.

KEYWORDS: Retaining-wall, cantilever retaining wall, relieving platform retaining wall, seismic motion response, seismic loading, design and analysis

I. INTRODUCTION

A retaining wall is a structure designed to sustain the earth behind it. It retains a steep faced slope of an earth mass against rupture of slopes faced slopes in cuts and fills and against sliding down. The retained material exerts a push on structures and this tends to overturn and slide it. Besides the self-weight, the main predominant force for analysis and design of the retaining wall is lateral earth pressure. The lateral earth pressure behind the wall depends on the angle of internal friction and the cohesive strength of the retained material, as well as the direction and magnitude of movement of the stems. Its distribution is typically triangular, least at the top of the wall and increasing towards the bottom. The earth pressure could push the wall forward or overturn it if not properly addressed. Retaining walls are encountered and constructed in various fields of engineering such as roads, harbours, dams, subways, railroads, tunnels, mines and military fortifications

[1] **YashChaliawala et al(2005)** has found that the behaviour and optimal design of two types of reinforced concrete walls of varying heights namely cantilever retaining wall, counter fort retaining wall. Cost against each optimal design of wall for particular height is calculated using the volume of concrete and the amount of steel. All most the cost estimate is chosen as the best design solution.

[2] **Punde Gayatri V., Auti Akanksha S., Yendhe Rutuja R., Yendhe Aishwarya A.,Shelar Trijeta R.(2018)** founded that the retaining structures hold back soil or other loose material where an abrupt change in ground elevation occurs. The retained material or backfill exerts a push on the structure and thus tends to overturn or slide it, or both. The cantilever is the most common type of retaining wall and is used for walls in the range of 3to 6m in height. This study presents analyses and design of cantilever retaining wall which is made from an internal stem of steel-reinforced, cast-in-place concrete (often in the shape of an inverted T). In this work a detailed analyses and design for this type of walls which include estimation of primary dimensions of the wall, then these dimensions were checked. The factor of safety against sliding, overturning and bearing were calculated. the shear resistance for the base, the tension stresses in the stem and the tension stresses for the base were checked. Calculation of reinforcement for each part of the wall was done. All analysis and design are based on the ACI code. There is a little experience in physical modelling of reinforced soil structure. The existing shear stack was of great help in a designing the two models. both where set up as full scale model or prototype with accordingly adapted dimension to avoid the breakage of reinforcement during testing , the quantity of geo-grids was a deliberately increase this way from the two limit state of internal stability ,only the pull out failure was allowed.

[3]. **Patilet al(2007)**, found that a retaining wall is one of the most important types of retaining structures. It is extensively used in variety

of situations such as highway engineering, railways engineering, bridge engineering and irrigation engineering. Reinforced concrete retaining walls have a vertical or inclined stem cast with base slab. These are considered suitable up to a height of 6m. It resists lateral earth pressure by cantilever action of stem, toe slab and heel slab. The tendency of wall to slide forward due to lateral earth pressure should be investigated and the factor of safety of 1.5 shall be provided against sliding. Cantilever retaining walls are found best up to a height of 6m for greater heights earth pressure due to retained fill will be higher due to lever arm effect higher moments are produced at base, which leads to higher section for stability design as well as structural design. This proves to be an uneconomical design. As an alternative to this, one may go for counter for retaining wall, which demands greater base area as well as steel. As a solution to this difficulty, a new approach that is to minimize effect of forces coming from retained fill, short reinforced concrete balance the locally appearing forces and will result into lesser moment and shear forces along the stem. Also it will reduce the bending action that is pressure below the base.

[4]. **Shejwal Neha, Danish Ali, Bhutekar S.B., Domale A.P. (2008)**found cantilever retaining walls are economically suitable for height up to 7.5m height and hence up to 7.5m no other alternate in necessary. There are many factors of safety consider while design of cantilever retaining wall such as overturning, sliding, earth pressures, self weight. The value s of these factors is gradually increases as increases in the height of retaining wall. Retaining structures hold back soil or other loose material where an abrupt change in ground elevation occurs. The retained material or backfill exerts a push on the structure and thus tends to overturn or slide it, or both. There are different types of retaining wall like Gravity, cantilever, counter fort, anchored retaining wall but cantilever is the most common type of retaining wall and is used for walls in the range of 6 to 7.5m in height. This study presents analyses and design of cantilever retaining wall for different height which is made from an internal stem of steel reinforced, cast-in-place concrete (often in the shape of an inverted T with shear key). In this work a detailed analyses and design for this type of walls which include estimation of primary dimensions of the wall, then these dimensions were checked. The factor of safety against sliding, overturning and bearing were calculated.

[5]. **S. Talatahari, R. Sheikholeslami, M. Shadfaran, M. Pourbaba(2012)**found that study focuses on the optimum design retaining walls, as one of the familiar types of the retaining walls which may be constructed of stone masonry, unreinforced concrete, or reinforced concrete. The material cost is one of the major factors in the construction of gravity retaining walls therefore, minimizing the weight or volume of these systems can reduce the cost. To obtain an optimal seismic design of such structures, this paper proposes a method based on a novel met heuristic algorithm. The algorithm is inspired by the Coulomb's and Gauss's laws of electrostatics in physics, and it is called charged system search CSS. In order to evaluate the efficiency of this algorithm, an example is utilized. Comparing the results of the retaining wall designs obtained by the other methods illustrates a good performance of the CSS. The potency of the PSO is summarized to find the direction of an agent's movement and therefore determining the acceleration constants becomes important. Similarly in the CSS method, updating is performed by considering the quality of the solutions and the separation distances between CPs. Therefore, not only the directions but also the amounts of movements are determined.

II. METHODOLOGY

The methodology worked out to achieve the above-mentioned objectives is as follows:

A. Design of retaining wall:-

Technically while designing, all the necessary parameters and requirements are considered and all the possible solutions are generated. Then a thorough analysis and calculations are carried out considering all the parameters especially cost involved and the risk and uncertainties involved. Then the solution with the optimal cost is chosen as the best solution. Thus, it is overall a rigorous decision making process.

The design of retaining will includes the following steps:

A. Fixation of the base width and the other dimensions of retaining wall

B. Performing stability checks and computation of maximum and minimum bearing pressure.

C. Design of various parts like stem, toe slab, heel slab, relieving platform

B. Design parameters:-

a. Length of relieving platform: It is kept equal to the length of heel slab for easy analysis purpose.

b. Thickness of relieving platform: It is considered as a one fourth of the thickness of base slab.

c. Location of relieving platform: It is considered at the mid height of the retaining wall.

d. Angle of friction (ϕ): 35º

e. Coefficient of active earth pressure (Ka): ((1-sin ϕ)/(1+sin ϕ))

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f. Coefficient of passive earth pressure (Kp): ((1+sin ϕ)/(1-sin ϕ))
g. Depth of foundation: Height or depth of foundation ranging from 1m to 2m is considered.
h. Soil bearing capacity: SBC is ranging from 100KN/m3 to 200 KN/m3.
i. Unit weight of soil (ϒs): 18 KN/m3
j. Unit weight of concrete: 25 KN/m3
k. Grade of concrete: M20
l. Grade of steel: Fe500

C. Static Stability analysis Checks:-

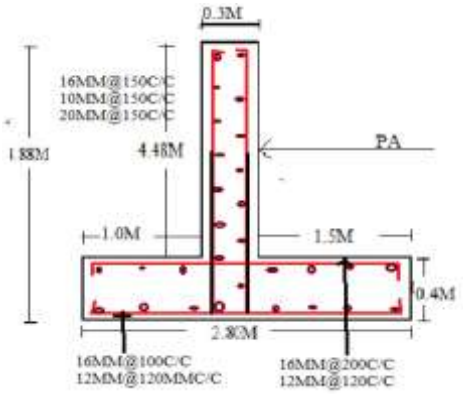
The following stability checks are used in the design of retaining wall
a. Eccentricity of the resultant reaction force should lie between 0 and the base width/6
b. Factor of safety against sliding is taken greater than 1.5
c. Factor of safety against overturning is also taken greater than 1.5
d. The maximum and minimum bearing pressure is taken greater than 0 and less than soil bearing capacity
e. Maximum and minimum reinforcement percentage and reinforcement spacing is taken as per IS456:2000 code.
f. Restrictions on maximum shear stress in different parts are based on concrete grade as per IS456:2000 code
D. Dynamic analysis of retaining wall
E. Cost comparison of both walls.

III. DESIGN OF RETAINING WALL

CASE I. Analysis and design of simple cantilever retaining wall using static loading condition:-

Step I:- Assumed data:-

1. Length of retaining wall:- 54m
2. Width of excavation being done:-3.2m
3. Depth of excavated foundation:-1.5m
4. Strata condition of foundation:- Hard rocky murrum type
5. Height of the retaining wall:- 4.1m
6. Top width of wall:-0.300m
7. Bottom width of retaining wall:-0.300m
8. Type of retaining wall:-Cantilever retaining wall.
9. Type of material to be retained by wall:-Murrum
10. Height of retaining material:-4.1 m
11. Soil bearing capacity (SBC):- 200 KN/m2
12. Unit weight of soil (ϒs): 18 KN/m3
13. Unit weight of concrete: 25 KN/m3
14. Grade of concrete: M20 = fck = 20N/mm2
15. Grade of steel: Fe500 = fy = 500N/mm2
16. Angle of internal friction (ϕ): 35º
17.Coefficient of friction between soil & concrete=μ=0.50
18.Design method= Limit state method



Showing the details of reinforcement in basic retaining wall.

CASE-II. Analysis and design of simple cantilever retaining wall with shelf using static loading condition:-

Step I:- Assumed data:-

1. Length of retaining wall:- 54m
2. Width of excavation being done:-3.2m
3. Depth of excavated foundation:-1.5m
4. Strata condition of foundation:- Hard rocky murrum type
5. Height of the retaining wall:- 4.1m
6. Top width of wall:-0.300m
7. Bottom width of retaining wall:-0.300m
8. Type of retaining wall:-Cantilever retaining wall with shelf.
9. Type of material to be retained by wall:-Murrum
10. Height of retaining material:-4.1 m
11. Soil bearing capacity (SBC):- 200 KN/m2
12. Unit weight of soil (ϒs): 18 KN/m3
13. Unit weight of concrete: 25 KN/m3
14. Grade of concrete: M20 = fck = 20N/mm2
15. Grade of steel: Fe500 = fy = 500N/mm2
16. Angle of internal friction (ϕ): 35º
17. Coefficient of friction between soil & concrete=μ=0.5
18. Design method= Limit state method

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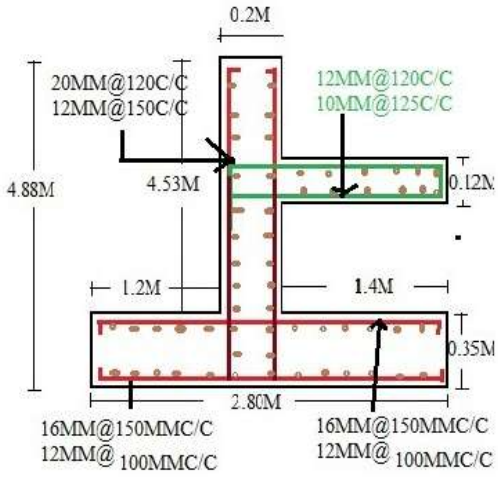

Showing the details of reinforcement in retaining wall with relief platform.

IV. RESULTS AND DISSCUSSION

Variation of bending moment:-

Wall type		**Bending Moment (Kn.m)**
Cantilever retaining wall		
	Stem	114.05
	Heel	52.86
	Toe	47.3475
Cantilever retaining wall with relief shelf		
	Stem	58.27
	Heel	49.26
	Toe	53.73
	Relief platform	30.24

As we see the bending moment for heel and toe is less in retaining wall with relief platform as reliving wall is reliving some bending moment..

Variation of Area of steel:-

Wall type		**Area of steel (mm^2)**
Cantilever retaining wall		
	Stem	1618.24
	Heel	812.58
	Toe	756.43
Cantilever retaining wall with relief shelf		
	Stem	1574.24
	Heel	853.54
	Toe	914.817
	Relief platform	1016.4

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As we see the area of steel for heel and toe is equal or less in retaining wall with relief platform. But the total area of steel for both the cases is almost same.

Variation of Area of concrete:-

Wall type		**Area of concrete (cum)**	**Total area of concrete (cum)**
Cantilever retaining wall			
	Stem	1.344	2.464
	Heel	0.72	
	Toe	0.4	
Cantilever retaining wall with relief shelf			
	Stem	0.906	2.054
	Heel	0.56	
	Toe	0.42	
	Relief platform	0.168	

As we see the area of concrete for heel, stem and toe is less in retaining wall with relief platform. But the total area of concrete for both the cases is also less as compare to other.

Variation of cost:-

Wall type		**Total area of concrete (cum)**	**Total area of steel (mm^2)**	**cost of concrete (per m)**	**cost of steel**	**Total cost**
Cantilever retaining wall						
	Stem	2.47	3188	20567.189	38256000	38276567.19
	Heel					
	Toe					
Cantilever retaining wall with relief shelf						
	Stem	2.06	4359	17153.18	43590000	43607153.18
	Heel					
	Toe					
	Relief platform					

As we can see the cost for steel in both the cases are almost same. But the cost for concrete is less for retaining wall with relieving platform than cantilever retaining wall. This is happened because when we provide platforms to the retaining wall the thickness of the base and the steam is reduces, and the volume of concrete is also reduces.

Stability consideration:-

From below table we can evident that FOS against overturning and sliding for both the wall are different as the relieving platform relive some factor of safety in both cases. But for the both cases, both the safety factors are almost 2 times greater in relieving platform retaining wall as compared to the cantilever retaining wall. So we can conclude that the relieving platform retaining wall is more stable and safe as compared to cantilever one.

Wall type	F.O.S AGAINST OVERTURNING>1.55	F.O.S AGAINST SLIDING>1.5
Cantilever retaining wall	3.96	2.36
Cantilever retaining wall with relief shelf	7.76	2.5

V. CONCLUSION

A retaining wall is one of the most important types of retaining structures. It is extensively used in variety of situations such as highway engineering, railway engineering, bridge engineering and irrigation engineering. This research aims at developing a relationship between various parameter of retaining wall and showing their comparative study.

- The bending moment in toe and heel is less for retaining wall with relieving platform than cantilever retaining wall.
- The area of steel for toe and heel is less for retaining wall with relieving platform than cantilever retaining wall.
- The construction cost for the retaining wall with relieving platform is more than cantilever retaining wall short height and less after that.
- The retaining wall with relieving platform is economical.
- By providing platform, the stability against sliding in increases much more. And the FOS again sliding and overturning is almost double in retaining wall with relieving platform than cantilever retaining wall.
- The retaining wall with relieving platform is much safer against overturning and sliding than cantilever retaining wall.
- And we also get inter-relationship between various parameters of retaining wall like dimensions, area of main steel, bending moments for different part of retaining wall and cost of construction.
- And also retaining wall with relief platform is more stable than simple type wall in dynamic seismic loading.

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