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Comparative Analysis of Earth Retaining Wall

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ABSTRACT*:* A retaining wall is one of the most important structures used in construction of railway tracks, bridge, highways. Retaining walls are structures designed to retain soil to a slope that it would not naturally keep to (typically a steep, near-vertical or vertical slope). Retaining walls are relatively rigid walls used for supporting soil laterally so that it can be retained at different levels on the two sides. The tendency of wall to slide forward due to lateral earth pressure should be investigated and a factor of safety of 1.5 shall be provided against silding. There are various types of retaining walls based on the retaining abilities.This paper consist of analysis and design of cantilever retaining wall with height 4.35m and SBC 150 KN/m^2.In present work, Earth pressure, stability and structural design comparison is done base for cantilever L shaped and Inverted T- shaped retaining wall..

KEYWORDS: Cantilever Retaining wall , design and analysis

I. INTRODUCTION

A retaining wall is a structure used to retain earth or other material and to maintain ground surface at different elevation on either side of it. Materials having tendency to slide and purpose at a particular inclination to retain such material wall is constructed that is retaining wall.
Retaining walls are relatively rigid walls used for supporting soil laterally so that it can be retained at different levels on the two sides). They are used to bound soils between two different elevations often in areas of terrain possessing undesirable slopes or in areas where the landscape needs to be shaped severely and engineered for more specific purposes like hillside farming or roadway overpasses.

II. AIM AND OBJECTIVE

Aim:-Comparative Analysis of Earth Retaining Walls.
Following are the objectives.

Objectives:-

1. To study the different types of retaining wall and their suitability.

2. To design selected types of retaining wall and compare the design.

III. LITERATURE REVIEW

1. Design of Rigid L- Shaped Retaining Walls.
Author: Ahmed Rouili
Year of Publication: 02 June 2014.
This paper presents the design starts by proportioning the wall dimensions for which the stability is checked In ratio between the lengths of the base and the stem, falling between 0.5 to 0.7 ensure in most case the stability requirements, however, the displacement pattern of the wall in terms of rotations and translations, and the lateral pressure profile, do not have the same figure for all wall's proportioning, as it is usually assumed. In the present work the results of a numerical analysis are presented, different wall geometries were considered.

2 .Design of Cantilever Retaining Wall with 4m Height.
Author: TamadherAbood, Hatem E.YounisEldawi, Faeza R. Elnaji Abdul Rahim
Year of Publication: April 2015 - September 2015
This paper presents that 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. .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 reinforcementfor each part of the wall were done.

3. Analysis and Design of Stepped Cantilever Retaining Wall.
Author: Dr. S.SPatil, A.A.R.Bagban
Year of Publication: 02, February-2015
This paper presents 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 a 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.

4.Design and analysis of retaining wall.
Author: Dr. Dhamdhere, Dr. V.R. Rathi
Year of Publication: Sep. 2018
This paper consist of analysis and design of cantilever retaining wall with varying height from 3m to 10m and SBC 160KN/m^2. Its show comparative study such as cost economy bending moment stability against overturning and sliding between both the retaining wall. In this paper comparative study is carried out along with the cost and optimum or least cost is chosen as the best option.

IV. METHODOLOGY

In present work following types of retaining wall are considered.
1. L-shaped Cantilever retaining wall.
2. T-shaped Cantilever retaining wall.

The comparsion is done regarding following:
1. Geometric design.
2. RCC Design using limit state method.

Design Parameters:
- Unit weight of soil (γ_1) =17KN/m^3
- Unit weight of soil (γ_2)=20KN/m^3
- Angle of friction (θ) = 30˚
- μ = 0.45
- S.B.C of soil = 150 KN/m^2.
- Grade of steel: Fe415
- Co-efficient of active earth pressure:

Ka= $\frac{1-\sin 30}{1-\sin 30}$

K_p = coefficient of passive earth pressure = $\frac{1+\sin\phi}{1-\sin\phi} = \frac{1}{k_a}$

- Stability Checks:

Overturning: $M_0 = P_a\frac{H}{3} = K_a\frac{\gamma H^2}{2}.\frac{H}{3} = K_a.\frac{\gamma H^3}{6}$

∴A minimum factor of safety of 2 should be used.
- Silding: F = $\mu\Sigma W$

∴ A factor of safety of 1.5 must be used against sliding.
- Soil Pressure:If ΣW is the sum of all vertical forces, and P_a is the horizontal active earth pressure, the resultant R will strike the base slab at a distance e (say) from the middle point of the base.

Let

$\sum M = W_1\bar{X}_1+W_2\bar{X}_2+W_3\bar{X}_3-Pa.\frac{H}{3}$

Then

$\bar{X} = \frac{\sum M}{\sum W}$

Hence eccentricity

e = $\frac{b}{2} - \bar{X}$

$P_1 = \frac{\Sigma W}{b}\left(1 + \frac{6e}{b}\right)$ At toe

And

$P_1 = \frac{\Sigma W}{b}\left(1 - \frac{6e}{b}\right)$ At heel

P_1 at toe should not exceed the safe bearing capacity of soil otherwise soil will fail. Similarly, P_1 at heel should be compressive. If P_2 comes to be tensile, the heel will be lifted above the will, which is not permissible. In an extreme case, P_2 may be zero, where e = b/6. Hence in order that tension is not developed, the resultant should strike the base within the middle third

Bending Failure: There are three distinct parts of T-shaped cantilever retaining wall the stem , the heel slab and toe Slab . The stem will bend as cantilever, so that tensile face will be towards the backfill. The critical section will be at, where cracks may occur at the inner face if it is not properly reinforced. The heel slab will have net pressure acting downwards, and will bend as a cantilever, having tensile face upwards. face. The net pressure on toe slab will act upwards, and hence it must be reinforced at the bottom face. The thickness of stem, heel slab and toe slab must be sufficient to withstand compressive stresses due to bending.

Table No 1: Geometric Details of the Retaining walls Considered for analysis and Design

Description	T-Shaped	L-Shaped
Total height	4.35m	4.35m
Base Width	2.65m	2.65m
Thickness of base Width	0.34m	0.34m,
Height of stem	4.01m	4.01m
Thickness of stem	0.165m	0.165m

From geometric Design carried out for L-shaped and inverted T-shaped cantilever retaining wall it has found dimensions of height, base width, thickness of base slab, height of stem are same for both retaining wall

Table No 2: Earth Pressure Diagram Comparsion

Description	T-Shaped	L-Shaped
Max Earth pressure at base of First strata	8.41 KN/m2	8.41 KN/m2
Max Earth pressure at base of retaining wall	25.31 KN/m2	25.31 KN/m2
Maximum upward soil pressure	90.58 KN/m2	144.92 KN/m2
Minimum upward soil pressure	29.44 KN/m2	26.52 KN/m2

From pressure diagram comparsion carried out for L-shaped and inverted T-shaped cantilever retaining walls, it has been found that maximum earth pressure at base of first strata and the maximum earth pressure at base of retaining wall for both the retaining walls are same. This is because the height of soil and Properties of soil are also same along the height of retaining wall.

The maximum upward soil pressure at the base for L-shaped retaining wall is more than inverted T- shaped retaining wall and minimum upward soil pressure is more for inverted T- shaped retaining wall then compare to L- shaped retaining wall.

Table No 3: Stability Comparsion

Description	T-Shaped	L-Shaped
Overturning Moment	78.147KN.m	78.147KN.m
Stabilising Moment	268.883KN.m	295.968KN.m
Total Silding Force	54.347KN	54.347KN
Frictional Force	71.56KN	102.22KN
Shear Key Requirement	Shear Key Required	Shear Key Not Required

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It has been observed overturning moment for inverted T-shaped and L-shaped retaining wall observed to be same. Stabilising moment for L-shaped retaining wall is observe more than that of inverted T-shaped retaining wall. Total silding for both the retaining wall is same.
Frictional force below the base of retaining wall is greater for L-shaped retaining wall more than inverted T- shaped retaining wall. Therefore for L-shaped retaining wall shear key not required and inverted T- shaped shear key required

Table No 4: Structural Design Comparsion

Description	T-Shaped	L-Shaped
Ast provided at stem	1827.83mm2	1827.83mm2
Ast provided at heel	5026.54mm2	1340.41mm2
Ast provided at toe	90.39mm2	-

Area of steel provided at stem is same for both the retaining wall. Area of steel provided at heel is more for inverted T-shaped retaining wall than of L- shaped retaining wall.

V. CONCLUSION

Base on above observation following conclusion are observed.

1. For given condition, It has been found that shear key is required for inverted T- shape Retaining wall and not for L-shape Retaining wall.
2. Area of steel required for stem is same for both type of retaining wall.
3. Area of steel required for heel slab is more for inverted T- shape retaining wall than L- shaped retaining wall.
4. Maximum upward soil pressure observed to be more in L- shaped retaining wall.
5. Minimum upward soil pressure observed to be more in inverted T- shaped retaining wall.

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