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RETAINING WALL WITH RELIEF SHELF

ShaikhIbrahim[1], Sami Akhtar[2], Md Sahid Anwer Momin[3], Sarfraj Jamadar [4], Mohammad Atiqueddin[5], Shaikh md fuzail [6]

[1]*Professor, Civil Engineering, Jamia Institute of Engineering & Management Studies, Maharashtra, 425415,India*
[2,3,4,5&6]*Final Year Student ,Civil Engineering, Jamia Institute of Engineering & Management Studies, Maharashtra, 425415,India*

Abstract - This paper consist of analysis and design of "Cantilever retaining wall with and without relief shelves,, and relieving thrust of lateral pressure on the wall. It also shows comparative study with varying height of 3.5m to 6m and S.B.C 120KN/m such as cost, economy, stability against overturning & sliding in retaining wall. In this paper we defines why the use of Relief shelves is a good option in CRW.

Key Words: Retaining wall, Cantilever Retaining wall, relief shelves (single shelf with horizontal/inclined surface), compare for stability analysis and design.

1. INTRODUCTION

Retaining walls are design and constructed to sustain the lateral Earth pressure of the earth behind the wall. When relief shelves are added on the backfill side of the wall. Such walls are called Retaining Walls with relief shelves, it can also be considered as a special type of retaining wall and also a functional solution to unstable and slope terrain .The relief shelves have the advantages of decreasing the acting lateral earth pressure and increasing the overall stability of the retaining wall. In some of studies say that using reinforced soil walls is the most economical method for constructing high CRW. It is noted that the relief shelves are able to reduce the total pressure by 38%.

1.1Defination of retaining wall:

Retaining wall is a structure that are designed and constructed to withstand lateral pressure of soil or hold back soil materials. The lateral pressure could be also due to earth filling, liquid pressure, sand, and other granular materials behind the retaining wall structure. There are various types of retaining wall structures which are used for numerous goals.

1.2 Types of Retaining Walls

1) Crib Retaining Wall
2) Gabion Retaining Walls
3) Cantilever Retaining Wall
4) Counter-fort / Buttressed Retaining Wall
5) Anchored Retaining Wall
6) Piled Retaining Wall
7) Mechanically Stabilized Earth (MSE) Retaining wall
8) Gravity Retaining Wall
9) Hybrid Systems

2. LITERATURE REVIEW

2.1 Reduction of surcharge induced earth pressure on rigid non-yielding retaining wall using relief shelves

VinayBhushanChauhan, Rizwan Khan, SatyanarayanaMurtyDasaka

In this paper the study of relief shelves on retaining wall to reduce the lateral earth pressure was done. They analyzed a model of retaining wall with 5 earth pressure sensors which were used to measure lateral earth pressure. A maximum surcharge pressure of 50 Kpa was applied on the backfill. From the results of the study, it is found that relief shelves are effective in reducing total thrust on wall through numerical analyses using FLAC3D software. They result obtained analyses revealed that provision of relief shelves on non-yielding rigid retaining wall provides significant reduction in total thrust on wall for 8m high retaining wall with three relief shelves. The reduction in lateral thrust is observed in the range of 11-26%.

2.2 Behavior of rigid retaining wall with relief shelves with cohesive backfill

V. B. Chauhan, S. M. Dasaka

In this paper the study of the possible reasons behind the failure of a cantilever retaining wall with relief shelves, which is located in the Hyderabad city, India. The height of the failed retaining wall ranges from 10 to 13.9m and retains a firm to stiff cohesive backfill, and constructed with 5 relief shelves from the preliminary post failure investigation. It is noted that quality of concrete used in construction was satisfactory, and the construction joint were intact from the preliminary analysis, it is noted that, through the lateral thrust on the retaining wall in the pressure of relief shelves is reduced up to 38%.

It is found that use of longer width of relief shelves has significantly increased bending stress in relief shelf as well as on the faces of stem of wall just the relief shelves. From the present study, it is noted that, this technique of reducing earth pressure on retaining walls may prove economical.

2.3 Retaining walls with relief shelves

Hany F. Shehata

In this paper the study of cantilever retaining wall with pressure relief shelves is considered as a special type of retaining wall.

The concept of providing pressure relief shelves on the backfill side of a retaining wall reduces the total earth pressure on the wall, which reduced thickness of wall and ultimately is an economic design of a cantilever wall. This paper presents a finite element analysis of this type of wall using PLAX-IS2D-AE.01.

The effects of providing one and two shelves as well as no shelves are discussed. The shelf significantly decreases the maximum bending moment and the top movement of the wall. This decreases in the lateral pressure increases the retaining structure stability.

2.4 Assessment of lateral earth pressure reduction using EPS geofoam-A numerical study

V. B. Chauhan, S. M. Dasaka

In this paper in the present study, effectiveness of EPSgeofoam on reduction of lateral earth pressure has been studied using numerical computation tool FLAC3D. This study revealed that provision of geofoam inclusion behind the rigid and nonyielding retaining wall provides controlled yielding of soil to mobilize its strength to reduce the lateral thrust on the retaining wall. It is noted that provision of geofoam behind the retaining wall provided a thrust reduction in range of 8-42% for surcharge pressure ranging from 10-50 Kpa.

The measured backfill surface settlement in case of 12D to 15D from in comparatively less than 10D, however it more than that of no. foam case (10D) is higher than stiffer geofoam, viz.12D and 15D.

2.5 Optimization and improvement in stability of counterfort retaining wall with relief shelf

Tonne V. R, Mohite P. M

In this paper the retaining structure are the walls meant to support earth or other material according to Khural R to achieve required formation width and to stabilize disturbed hill slopes number of retaining structures are constructed in hilly terrain it's construction cost is near about 20% to 30% of hill roads project cost.

Gravity retaining walls are designed by considering its shape and size. Its stability is depending on its dimensions. When height of earth mass to be retained is less than 6m height counterfort retaining wall of heights 10m, 12m and 15m with relief shelf at h/2 gets minimum earth pressure minimum overturning moment and better stability (where h= height of stem)

It results in reduction in cross section of retaining wall by 49.86% in 10m, 49.84% in 12m and 43.75% in 15m height of wall.

2.6 Optimum static analysis of retaining wall with & without shelf shelve at different level using finite element analysis

D. N. Shinde

In this paper retaining wall with pressure relief shelves is one of the special types of retaining wall. High reinforced concrete wall with relief shelves on the back fill side of wall such wall may be termed as the retaining wall with relief shelf. Lateral earth pressure on wall and increasing overall stability of the structure. This results in an economical design because less material goes into the wall as compared to massive structure of cantilever or even counterfort retaining walls without shelves. The finite element analysis of 2D model of retaining wall by using STAAD-PRO is performed in this work. The software STAAD-PRO can be suitably applied for the structural analysis such type of wall.

The best location for the single shelf is observed to be in between 0.4h to0.5 for the maximum reduction in the earth pressure less bending moments and less deflection. The deflection of the stem is reduced by about 41-50% by providing shelf at 0.5h than the deflection given without shelf.

3. ANALYSIS AND DESIGN

1) The following problems were considered in scope of this study:
2) Cantilever wall without shelf
3) Cantilever wall with single shelf with horizontal surcharge
4) Cantilever wall with single shelve with inclined surcharge.

The detailed analysis, design and special considerations made for each of above problem is described in their respective sections.

Common consideration for all problems:

For further comparison purpose, a retaining wall with equal data is considered in all problems. Main focus was on stem analysis, so 6 m stem is considered in all problems and based on this depth of foundation and height of wall is calculated.

- Height of Wall (H)= 6 m
- Backfill is Horizontal
- Density of soil= 18 KN/m^3
- Safe bearing capacity of soil is: 200 kN/m^2.
- Co-efficient of friction between concrete and soil as 0.5.
- The angle of repose is 30°.
- Coefficient of active earth pressure (Ka) = 0.333.
- Use M20 concrete and Fe415 steel.

3.1Analysis and Design of Cantilever Retaining Wall without Shelf

Analysis and design of cantilever wall is done for per meter length of the wall. Analysis of stem, heel slab and toe slab is done as cantilever beam and designed likewise.

Table 3.1.1: Value of BM (kNm) And Area of BMD(kNm2) for CW

BM at the base of stem	**216 (kNm)**
Area BMD	**324 (kNm^2)**

Table 3.1.2: Quantities of steel and concrete for cantilever retaining wall

Components	**Quantities(m3 or kg)**
Concrete	
Stem	1.8 m3.
Base slab	1.44 m3.
Total quantity of concrete	**3.24 m3.**
Steel	
For Stem	
Main Steel	178.58
Distribution Steel	23.68
For Heel	
Main Steel	56.22
Distribution Steel	9.08
For Toe	
Main Steel	8.17
Distribution Steel	3.56
Steel for shear reinforcement	2.75
Total quantity of steel	**282.04 kg**

3.2Analysis and Design of Cantilever Retaining Wall with Shelf

Analysis and design of cantilever wall is done for per meter length of the wall. Analysis of stem, shelf, heel slab and toe slab is done as cantilever beam and designed likewise.

Table 3.2.1: Quantities of steel and concrete for cantilever retaining wall with shelf

Components	**Quantities(m3 or kg)**	
Concrete		
Stem	1.8 m3.	
Shelf	0.36 m3.	
Base slab	1.44 m3.	

Total quantity of concrete	**3.6 m3.**	
Steel	**As per IS code provision**	**Required Steel**
For Stem and Shelf		
For Shelf		
Main Steel	28.32	28.32
Distribution Steel	5.31	5.31
For stem part 2 to 3		
Main Steel	22.28	22.28
Distribution Steel	12.19	12.19
For stem part 3 to 5		
Main Steel	5.38	5.38
Distribution Steel	3.68	3.68
For stem part 5 to 1		
Main Steel	21.66	21.66
Distribution Steel	10.29	10.29
For Heel		
Main Steel	16.67	16.67
Distribution Steel	11.11	11.11
For Toe		
Main Steel	5.72	5.72
Distribution Steel	5.59	5.59
Steel for shear reinforcement	2.33	1.51
Total quantity of steel	**150.66 kg**	**133.95 kg**

3.3 Analysis and design of retaining wall with relief shelf with inclined surcharge

Analysis and design of cantilever wall is done for per meter length of the wall. Analysis of stem, heel slab and toe slab is done as cantilever beam and designed likewise.

3.3.1Quantities of steel and concrete for cantilever retaining wall with shelf

Components	**Quantities (m^3 or Kg)**
Concrete	
Stem	1.8
Shelf	0.36
Base slab	1.44
Total quantity of concrete	**3.6**
Steel	
For steam and self	
For shelf	
Main Steel	35.39
Distribution steel	5.31
For stem part 2 to 3	
Main steel	25.46
Distribution steel	12.19
For steel part 5 to 1	
Main steel	18.48

Distribution steel	10.29
For heel	
Main steel	16.67
Distribution steel	11.11
For Toe	
Main steel	5.48
Distribution steel	5.59
Steel for shear reinforcement	2.33
Total quantity of steel	**157.11 Kg**

4. RESULTS AND DISCUSSION

4.1 Comparison of stability check for different cantilever retaining wall models

The table 4.1 shows comparison of stability check for different cantilever retaining wall models. From table 4.1 it is observed that, the corresponding values for overturning and sliding for models with shelf are safer as compared to model without shelf keeping all dimensions same for all models taken into comparison.

Table 4.1: Comparison of stability check for different cantilever retaining wall models (Height H = 6m)

Model→ / **Stability check ↓**	**Model 1:** **Cantilever wall without shelf**	**Model 2:** **Cantilever wall with single shelf with horizontal surcharge**	**Model 3:** **Cantilever wall with single shelf with inclined surcharge**
Overturning	2.83 > 2	3.86 > 2	3.83 > 2
Sliding	1.55 > 1.5	2.6 > 1.5	2.42 > 1.5
Check	Safe	Safe	Safe

4.2 Comparison of various cantilever retaining wall models

The table 4.2 shows comparison of steel quantity for various cantilever retaining wall models. From table 4.2 it is observed that, the economic shelf location for Cantilever wall with single shelf with horizontal surcharge is at 7H/12 and that of Cantilever wall with single shelf with inclined surcharge is 6H/12. The steel quantity required for models with shelf is considerably less as compared to model without shelf.

Table 4.2: Comparison of various cantilever retaining wall models (Height H = 6m)

Quantities	**Model 1:**	**Model 2:**	**Model 3:**
	Cantilever wall without shelf	**Cantilever wall with single shelf with horizontal surcharge**	**Cantilever wall with single shelf with inclined surcharge**
Economic shelf Location: (Distance	-------	7H/12	6H/12

From Top of Stem)			
Steel in Kg	282.04	133.95	157.11
Concrete in m3	3.24	3.24	3.6
Comparison of steel with Model 1	-------	52.51 % less	**55.70% less**
Comparison of steel with Model 2	-------	-------	17.29 % more

THE BENEFITS OF INSTALLING A RETAINING WALL

a) ***Structural support***

b) ***Preventing soil erosion and providing flood control***

c) ***Adding functional space to your yard***

d) ***Aesthetics***

5. ADVANTAGES OF RETAINING WALLS

One of the biggest challenges to construction is dealing with steep slopes and difficult grades. There is a huge concern for erosion and even planting difficulties. A retaining wall is the solution for construction in such areas. This kind of wall or system of walls holds back the earth and water. Coupled with drainage systems, retaining walls can reduce and manage storm water. They create a strong barrier to enhance the landscape making it more functional.

Retaining walls are made of various materials including natural stone and interlocking concrete blocks. Regardless of the type of material used, the purpose of the retaining wall is to create terracing in a sloping area and hold all the soil in place.

High impact landscaping

Retaining walls provide terracing for planting flowers, landscaping features and establishing a gateway to the property. This is quite common with commercial properties such as resorts, golf clubs and even office buildings that require a dramatic entrance. This robust landscaping creates a signage and enhance the overall appearance of

property. The same can be applied on a residential property on a smaller scale.

Expanding usable land

Sloppy or mountainous landscape can lead to quite a lot of restrictions over the kind of construction that can be carried out on that piece of land. In order to create more usable space on a property, positioning retaining walls in parts of the land that are not accessible or safe can create spaces for patios and walkways.

Protecting the land from erosion

Erosion is a problem when the soil and all of its contents are washed down into storm water sewers and waterways. Erosion also poses a safety risk on steep slopes because the rushing water can destroy the land. Setting up retaining walls with a good drainage system mitigates these risks.

Adding property value

Adding retaining walls Raleigh NC is an easy and affordable way to increase the value of property. You can create a wall using natural materials in your residential gardens and add versatility to the space around your home. These valuable additions can significantly increase the market appeal of your property.

Easy to maintain and durable

Retaining walls are extremely low maintenance, especially with good construction. Once the wall is built to your liking, you can leave it alone. Retaining walls made of natural materials such as rocks can withstand harsh weather conditions. Creating walls using natural materials means you have access to locally and cheaply available materials even in times of repair.

5.1 THE DISADVANTAGES OF RETAINING WALLS

Retaining walls are one of the most common structural tools for landscaping. A retaining wall is a wall used in landscaping as a stabilising structure for sloping soil. No matter the type of retaining wall, it must be sturdy enough to disperse pressure caused by sloping. If you are thinking of using a retaining wall for your landscaping project, familiarise yourself with the disadvantages of retaining walls, before making the commitment to install one.

Vertical Cracks

Some retaining walls begin developing vertical cracks, such as in poured concrete. This is often due to excessive pressure or wide changes in temperature. In order to prevent these vertical cracks, provide plenty of good drainage, which can often be expensive to accomplish.

Failing Foundation

Retaining walls need extensive drainage resources to prevent moisture, but they also require a strong foundation. Some retaining walls will not be able to retain high amounts of pressure from soil, such as bricks walls. This often results in crumbling bricks or a failing foundation.

Termites

Retaining walls also can attract termites to your property, as is often the case when timber is used as a retaining wall. Termites can nest inside rotting timber and near moulded areas. Correcting this problem can be expensive, if you have to use termite monitoring and treatment devices.

6. FUTURE SCOPES

1. CWR with relief shelf will reduces the total lateral pressure of the soil.

2. CWR with relief shelf is more economical than without cantilever wall.

3. This construction technique has been adopted as more beneficial & more stable. In terrain areas this techniques helps to prevent sliding and where the lateral pressure is heavy.

4. It's stability enhance the safety in terrain areas.

7. CONCLUSIONS

The conclusion of the study are listed below,

1. "Retaining walls with shelves" are economical compared to conventional "retaining wall without shelves".

2. The economic shelf location for cantilever retaining wall with single shelf for uniform surcharge is at 7H/12 and for inclined surcharge is at 6H/12 from top of the stem, where H is height of stem.

3. The economic shelf location for cantilever retaining wall with propped simply supported shelf is at 6H/12 from top of the stem.

4. Cantilever Retaining walls with single shelve is economical as compared to cantilever wall without shelf.

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