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Optimum Static Analysis of Retaining Wall with & without shelf /Shelve at different level using finite Element analysis

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Abstract— Retaining wall with pressure relief shelves is one of the special types of retaining wall. High reinforced concrete retaining walls may be used economically by providing relief shelves on the back fill side of wall. Such walls 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 the shelves.

Keywords- Retaining Wall ,Retaining Wall with shelve,Stadd pro V8i.

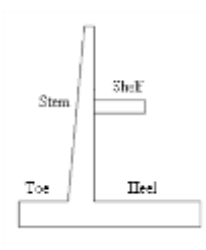
INTRODUCTION

A retaining wall is a structure designed to sustain the lateral pressure of earth behind it. It retains a steep faced slope of an earth mass against rupture of slopes in cuts and fills and against sliding down. The retained material exerts a push on structure and this tends to overturn and slide it. The weight of retaining wall is considerable significance in achieving and maintaining stability of entire system. Earth retaining structures may be retaining walls, sheet piling, bulkheads, and basement walls, other permanent, temporary structures used in earth works and foundation engineering that retain vertical or almost vertical slopes of earth masses.

The lateral force acting between retaining structure and retained earth mass is termed as lateral earth pressure which is predominant force for analysis of retaining wall. Retaining walls are encountered and constructed in various fields of engineering such as roads, harbors, dams, subways, railroads, tunnels, mines, and military fortifications.

A continuous investigation and study is going on the various types of retaining walls for achieving optimum economy, developing speedy and easy construction processes, reducing section of wall components and ultimately to get the wall of maximum strength and durability. This is possible only by reducing the earth pressure behind the wall. Various techniques have been developed for reducing the earth pressure behind wall.

1)Retaining wall Without Shelve (Fig no. 1a)



2) Retaining Wall With Shelve(Fig no.1b)

STRUCTURE MODELING

A design example is given here to understand the procedure used in the analysis of retaining wall in this study. Analysis and design has been carried out by considering the stated properties of cohesion less backfill and also height of backfill to be retained for cantilever retaining wall and cantilever retaining wall with relief shelf at center of height of retaining wall. The tentative dimensions for cantilever retaining wall are adopted based on prevailing thumb-rules. The detail calculations for cantilever retaining wall and

cantilever retaining wall with relief shelf at center of height of retaining wall are given and the calculated results have been presented. At the end the calculated results for different cases are presented in the tabular form.

MODEL DISCRIPTATION : 1) CONVECTIONAL METHOD:

a) Cantilever Retaining Wall without Shelf : (Following data is assumed.)

Height of backfill to be supported (H) *= 7 m*

Unit weight of soil (**γ**) = 20 KN / m^3

Angle of internal friction (**ø**) = 30^0

Coefficient of friction at base (0.5) = 0.5

Bearing Capacity of soil (q_f) = 200 KN / m^2

Unit weight of reinforced cement concrete = 25 KN / m^3

Grade of concrete: M 20 and grade of steel: Fe 415

Section of retaining wall:

Width of base slab (B) = 3.8 m (0.4 H to 0.7 H)

Thickness of stem at top of retaining wall (T_0) = 0.40 m

(200 mm minimum, preferably 400 mm)

Thickness of stem at intersecti = 0.8 m (H/12 to H/8)

of stem and base slab (T_s)

Thickness of base slab (T_b) = 0.8 m (H/12 to H/10)

Height of stem (h) = H – t_b = 7.00 – 0.80 = 6.2 m

Projection of base slab towards toe = 1 m

(0.20 B to 0.40 B)

b)Cantilever Retaining Wall with Relief Shelf at mid height of Retaining wall: (Following data is assumed.)

a) Height of backfill to be supported (H) *= 7*

Unit weight of soil (**γ**) = 20 KN / m^3

Angle of internal friction (**ø**) = 30^0

Coefficient of friction at base (0.5) = 0.5

Bearing Capacity of soil (q_f) = 200 KN / m^2

Unit weight of reinforced cement concrete = 25 KN / m^3

Grade of concrete: M 20 and grade of steel : Fe 415

Section of retaining wall

Width of base slab (B) = 3.8 m (0.4 H to 0.7 H)

Thickness of stem at top of retaining wall (T_0) = 0.40 m (200 mm minimum preferably 40mm)

Thickness of stem at intersection = 0.8 m (H/12 to H/8)

of stem and base slab (T_s)

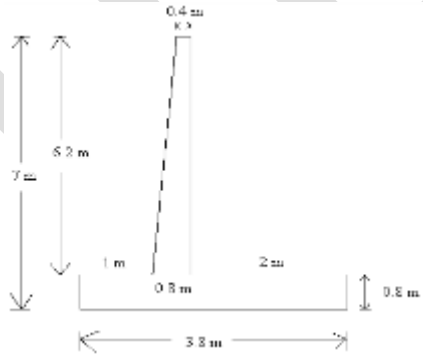
Thickness of base slab (T_b) = 0.8 m (H/12 to H/10)

Height of stem (h) = H – t_b = 7.00 – 0.80 = 6.2 m

Projection of base slab towards toe (0.20 B to 0.40 B) = 1 m

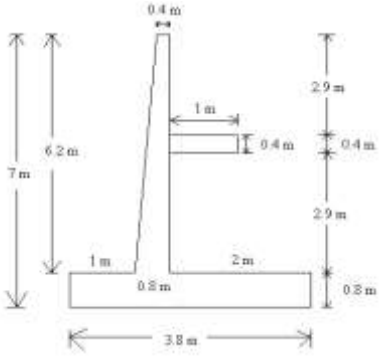
Relief Shelf projection towards backfill (b) = 2/2 = 1 m

Thickness of relief shelf = Base slab thickness / 2 = 0.80 / 2 = 0.4 m



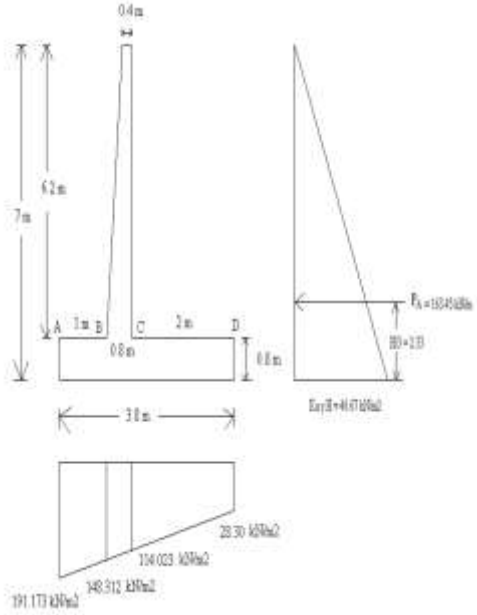
(a)
(Unsafe against Sliding)

(Fig no.2a)

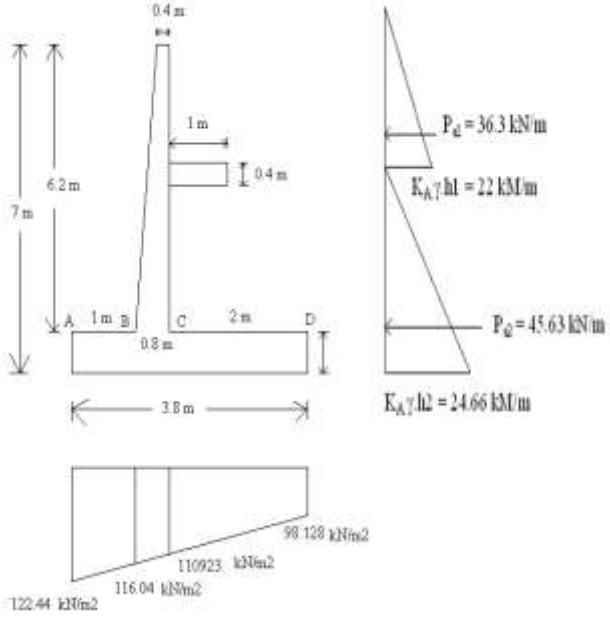


(b)
(Safe Against Sliding)

(Fig no.2b)



Pressure distribution diagram for Retaining wall without shelf(Fig no 3a)



Pressure distribution diagram for Retaining wall without shelf(Fig no 4b)

RESULTS AND DISCUSSION

Table No1) Comparison between retaining wall without and with shelf

Sr. No	Description	Retaining Wall without Shelf	Retaining Wall with Shelf
01	Eccentricity from toe	0.47	0.0698
02	P_{max} (Pressure intensity at Toe)	191.173 kN/m^2	122.42 kN/m^2
03	P_{min} (Pressure intensity at Heel)	28.30 kN/m^2	98.128 kN/m^2
04	Active Earth Pressure	163.34 kN/m	64.34 kN/m
05	Factor of safety against sliding	1.27 (Unsafe)	3.25
06	Factor of safety against overturning	2.56	4.63
07	Volume of concrete		

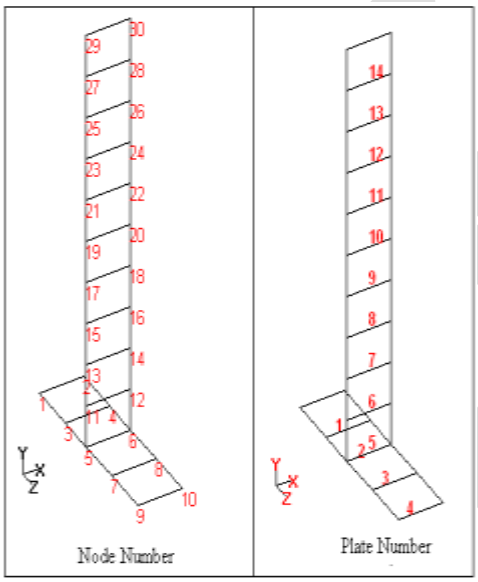
	i) Base slab	3.04 m^3	3.04 m^3
	ii) Stem	3.72 m^3	3.72 m^3
	iii) Shelf	-----	0.4 m^3
	Total volume of concrete required	6.76 m^3	7.16 m^3
08	Area of reinforcement		
	a) Toe of base slab i) Longitudinal steel ii) Distribution steel	930.60 mm^2 960 mm^2	879.08 mm^2 960 mm^2
	b) Heel of base slab i) Longitudinal steel ii) Distribution steel	1418.63 mm^2 960 mm^2	720.66 mm^2 960 mm^2
	c) Stem i) Longitudinal steel ii) Distribution steel	1736.20 mm2 720 mm^2	1410 mm^2 720 mm^2
	d) Relief Shelf i) Longitudinal steel		

	ii) Distribution steel	------ ------	622.34 mm^2 480 mm^2
	Total area of reinforcement required	6725.43 mm^2	6752.08 mm^2

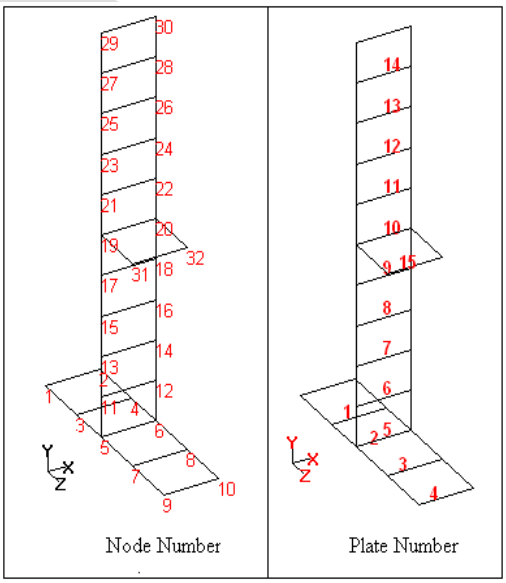
STADD PRO METHOD:

Model of retaining wall without and with shelf in STAAD-Pro :

STAAD-Pro is used to perform finite element analyses of retaining wall without and with shelf. The model of the cantilever reinforced concrete retaining wall without and with shelf is generated in Space structure (which is a three-dimensional framed structure with loads applied in any plane) and using four noded plate element. The model of the retaining wall without shelf includes 30 nodes and 14 plates and the wall with shelf includes 32 nodes and 15 plates. Node no. 1 to 6 on toe slab, node no. 5 to 10 on heel slab, node no. 5, 6, 11 to 30 on stem on node no. 31 & 32 on shelf. Node no. 5& 6 is common for toe, heel and stem. Plate no. 1 & 2 on toe slab, plate no. 3 & 4 on heel slab, plate no. 5 to 14 on stem on plate no. 15 on shelf. Figure no. 4.1 and 4.2 show the Node no. and plate no. for retaining wall without and with shelf.



Node no. and plate no. for retaining wall without shelf (Fig no.4a)



Node no. and plate no. for retaining wall with shelf (Fig no.4b)

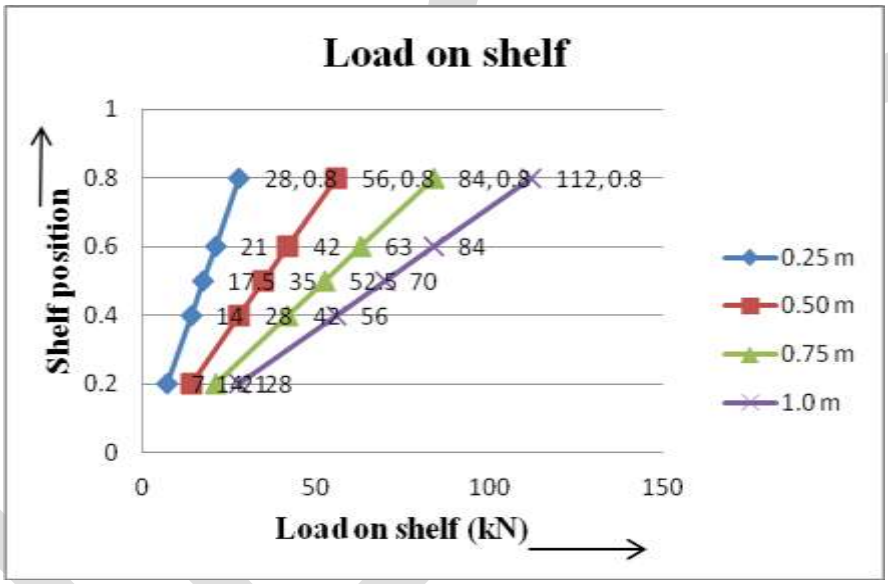
Analysis of retaining wall with shelf by changing the locations and width of shelf

The analysis of retaining wall with shelf is performed by changing locations i.e. shelf is located at 0.2h, 0.4h, 0.5h, 0.6h & 0.8h from top where h is height of retaining wall and also by changing width i.e. shelf width is provided 0.25 m, 0.50 m, 0.75m & 1.0m.

Combination of location and width

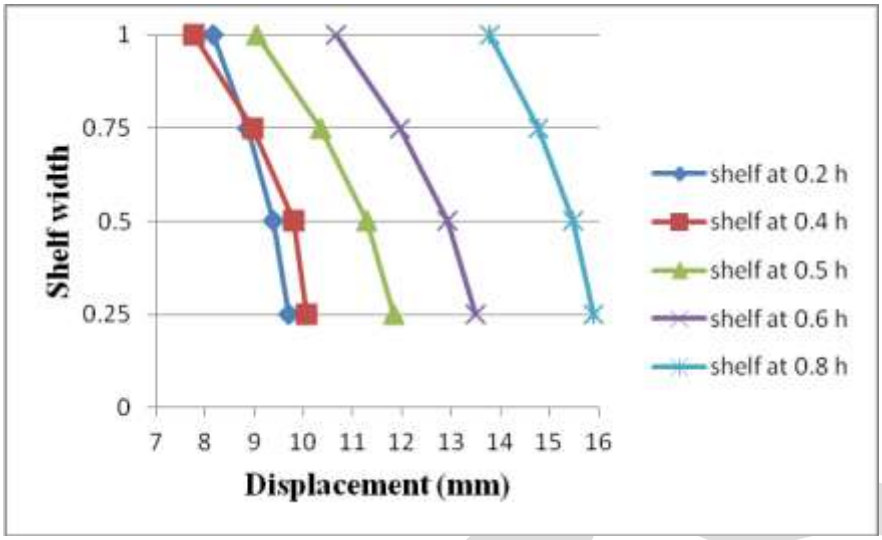
Table No2) : Combination of location factor and shelf factor

Combination	Shelf width	Shelf location from top				
Combination 1	0.25 m	0.2 h	0.4 h	0.5 h	0.6 h	0.8 h
Combination 2	0.50 m	0.2 h	0.4 h	0.5 h	0.6 h	0.8 h
Combination 3	0.75 m	0.2 h	0.4 h	0.5 h	0.6 h	0.8 h
Combination 4	1.0 m	0.2 h	0.4 h	0.5 h	0.6 h	0.8 h



Load on shelve (Graph 1)

Graph1: shows the values of load on shelf due to earth pressure. Load on shelf increases with changing the location of shelf as well as with increasing the shelf width.



Displacement of top node for shelve width :(Graph 2)

Table No3): Displacement of top node

Shelf width	Shelf position (Displacement in mm)				
	0.2 h	0.4 h	0.5 h	0.6 h	0.8 h
0.25 m	9.699	10.076	11.838	13.494	15.902
0.50 m	9.390	9.806	11.278	12.925	15.480
0.75 m	8.876	8.959	10.345	11.977	14.776
1.0 m	11.156	7.773	9.038	10.651	13.792

CONCLUSION

The retaining wall with relief shelf is proved to be advantageous over the cantilever and counterfort retaining wall. The finite element analysis of 2-D 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 of such type of wall. The study of deflections, bending moment, support reactions, etc. on various components of retaining wall can be easily performed by this software.

Following are the concluding remarks…..

1. The best location for the single shelf is observed to be in between 0.4 h to 0.5 h for the maximum reduction in earth pressure, less bending moments and less deflection.
2. The deflection of the stem is reduced by about 41.50% by providing shelf at 0.5 h than the deflection given without shelf.
3. The deflection of the stem depends mainly on the shelf location and it increases for the shelf located from 0.2 h to 0.8 h.
4. The deflection reduces by increasing the width of the shelf but the variation is less.
5. The pattern of occurrence of bending moment on toe for all the shelves (0.25 m, 0.50 m, 0.75 m, 1.0 m) is same in X & Y direction.
6. Displacement of shelf reduces as the width of shelf increases at a particular location.
7. Self weight of retaining wall with shelf increases due to which stability force increases and retaining wall become more stable.

REFERENCES:

[1] Suliman B.A.Mohamed,Kuo-Hsing Yang.(2014):Finite element analyses of two-tier geosynthetic reinforced soil wall comparison involving centrifuge test and limit equilibrium results.

[2] Padhye R. D. (2010),Ph.D. thesis on *"Analysis and Design of Retaining Walls with Pressure Relief Shelves".*

[3] Syed Mohd. Ahmad and P. K. Basudhar, (2008) *"Behaviour of reinforced soil retaining wall under static loading using finite element method"*The 12th International Conference

[4] Kevin Abraham (2007), *"Three dimensional behavior of retaining wall systems,"* A Dissertation for the degree of Doctor of Philosophy. The Department of Civil and Environmental Engineering. M.S., MississippiStateUniversity.

[5] P.E.Pinto and C.G.Lai (2006) "Numerical Modelling & Seismic Behavior of Earth Retaining Walls".

[6] Padhye R. D. &Ullagaddi P. B., (2005), *"Retaining Walls with Pressure Relief Shelf – A Review Study",* All India Seminars on, "Advances in Geotechnical Engineering". National Institute of Technology, Rourkela. pp 62 – 68.

[7] Varghese P.C. (2005), *"Foundation Engineering"*, Prentice Hall of India Pvt. Ltd. New Delhi.

[8] Seung –Hoon Lee, Buhm soo Chang (2004) Two-Parameter Beam-column model and back analyses for flexible Earth retaining walls.

[9] J.R.Blake, J.P.Renaud ,M.G.Anderson,(2003)Prediction of rainfall-induced transient Water pressure behind a retaining wall using a high resolution finite element model.

[10] Ray Chaudhuri P. et al (1973), Paper No. 295. "*Design of Retaining Walls with relieving shelves"* IRCJournal, Volume 35, part 2, pp 289 - 325.

[11] G. Wayne Clough and James M. Duncan, (1971) "*Finite Element Analyses of Retaining Wall Behavior*"Vol. 97, No. 12, pp. 1657-1673.

[12] Jumikis A. R. (1964), *"Mechanics of Soils"*, D. Van NostrandCompanInc, PrincetonNJ.