Optimum Static Analysis of U Type Retaining Wall With & Without Shelf At Different Level Using Staad Pro

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Abstract- *Retaining wall of U type with pressure relief shelf is one of the special types of retaining wall. Reinforced concrete U type retaining walls can be used in a variety of engineering fields such as roads, dams, tunnels and mines were the safe bearing capacity of the soil is relatively very low. Reinforced concrete retaining walls are meant to support more height of earth mass. When U type retaining wall is constructed for 6m and above may lead to uneconomical design. When considering retaining walls of greater height, it can be effectively used if shelf is provided in the stem. To support greater height of earth mass, advancement is done in U type retaining wall by adding relief shelf. This paper conducts a thorough analysis of the design measures taken of u type RCCRetaining Walls with Single shelf and without Shelf. Due to provision of relief shelf the soil pressure on the retaining wall is reduced resulting in improvement in stability of retaining wall. In this paper analysis of retaining wall with one relief shelf is done for various positions of relief shelf. These results are studied to get minimum earth pressure, more stability and minimum moment in each component of retaining wall.*

U type retaining wall with pressure relief shelf is considered as a special type of retaining wall but shapes of the measured earth pressure distributions differ among studies because the model scales were affected as when one measurement was permitted to move restriction was to be provided to move in the other measurements as per design criteria. Pressure quantity, the maximum acting bending moment and shear force on the wall have been thoroughly analysed and its performance have been checked for the retaining design. As per numerical study and analysis conducted to investigate the effect of the number of shelf and wall stem rigidity and shelf horizontal location on the resulted lateral earth pressure distribution, it was found that the shelf have a significant effect on the distribution of the earth pressure. Pressure quantity, the maximum acting bending moment and shear force on the wall are also discussed to perform the retaining design.

Keywords- U type Retaining Wall; U type Retaining Wall with shelf, STAAD Pro V8i, EARTH PRESSURE

I. INTRODUCTION

Retaining walls are constructed to sustain the lateral pressure of the earth behind them. Retaining walls are very much necessary in some of the fields such as roads, dams, rail road's, tunnels and military foundation etc. It retains a steep faced slope of an earth mass against rupture of slopes in cuts and fills and against sliding down. The weight of retaining wall is considerable significance in achieving and maintaining stability of entire system. Retaining wall consists of 3 parts they are stem, Base slab and shelf. A continuous work is carried out by the researchers for increasing the construction economy of a retaining wall.

Retaining walls with relief shelf can also be considered as a special type of retaining walls. The concept of providing pressure relief shelf towards the active soil mass side of a retaining wall reduces the total earth pressure on the wall, which results in reducing the thickness of the wall and ultimately to get an economic design by use of less reinforcement on wall horizontal cross section on the level of contraction joints. Some reports by engineers have stated that using reinforced soil walls is the most economical method for constructing high walls without studying walls with shelf in their reports. Lateral earth pressures are zero at the top of the wall and in homogenous ground increase proportionally to a maximum value at the lowest depth. Earth pressures will push the wall forward or overturn it if not properly designed. The total pressure or thrust may be assumed to act at one-third from the lowest depth for lengthwise stretches of uniform height.

The relief shelf has the advantages of decreasing the acting lateral earth pressure and increasing the overall stability of the retaining wall. If there is a construction near the wall and if the soil reinforcement cannot be applied, the use of this type of wall can be the most effective tool toward cost

reduction and overall safety improvement. Adding shelf to a cantilever retaining wall may be a solution toward achieving stability and cost control. The study of this type of retaining wall is a somewhat un-noticed area in the study of retaining structures. Few studies have been carried out on the real behaviour of this type of wall. Therefore, studying the effectiveness of this type of retaining wall is required for its use in practical application. Case studies are also required to present the most economical solution to the practice in various cases.

II. LITERATURE REVIEW

1] Chougule, A. C., J. P. Patankar, and P. A. Chougule carried out a study to identify Effective Use of Shelves in Cantilever Retaining Walls. This paper conducts a thorough analysis of the design measures taken of RCCRWs with 1) Single and Double shelves, and 2) Without Shelves. The paper concludes that the best location for a shelf for single shelf retaining walls is at 7/12th of stem height from top and the best locations for two shelves for double shelf retaining wall is at 4/12th of stem height and 7/12th of stem height from top. By this way they concluded that a retaining wall with shelves, as the height of the wall increases, percentage saving of material increases. Cantilever Retaining walls with two shelves are economical as compared to cantilever wall with single shelf.

2] **Shinde, D. N., and Mr Rohan R. Watve** carried out a study to identify Optimum Static Analysis of Retaining Wall with & without shelf/Shelve at different level using finite Element analysis. This paper conducts 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. This paper contain following are the concluding marks:-

i. 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.
ii. The deflection of the stem is reduced by about 41.50% by providing shelf at 0.5 h than the deflection given without shelf.
iii. 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.
iv. The deflection reduces by increasing the width of the shelf but the variation is less.
v. 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.
vi. Displacement of shelf reduces as the width of shelf increases at a particular location.
vii. Self weight of retaining wall with shelf increases due to which stability force increases and retaining wall become more stable.

3] **Hany F. Shehata** stated that Retaining walls with relief shelves represented Finite Element analysis of this type of wall using PLAX-IS2D-AE.01. The reduced total active earth pressure due to the provisioning of shelves is depicted. It was found that the shelves had a significant effect on the resulting earth pressure distribution. The distribution approximately followed the distribution of the solution by Klein (Calculation of retaining walls (in Russian). Vysshaya Shkola, Moscow, 2014). It also followed the shape of the measurements of Yakovlev (Experimental investigation of earth pressure on walls with two platforms in the case of breaking loads relieving on the backfill. Odessa Institute of Naval Engineers, pp 7–9, 1974). A parametric study was conducted to enable a discussion of the effects of the number of shelves, shelf rigidity, and shelf position on the resulting distribution of the lateral earth pressure, wall top movement, and acting maximum flexural moment of the wall. For high retaining walls and for some repair systems for constructed walls that have problems with stability, it is recommended to provide the cantilever wall with a shelf at a third of the wall height from the top of the wall or more shelves at different levels. Suggested updates are provided to enhance the manual solution of Klein in the calculation of the acting maximum bending moment of the wall.

4] **Chadhuri, P. R., A. K. Garg, P. R. R. Bhaskarai, R. N. Sharma and P. D. Satija** studied Design of retaining walls with relieving shelves. This paper brings out the advantages of providing a relief shelf in the conventionally designed cantilever and counterfort type retaining walls. Both the theoretical and practical aspects of the modified active earth pressure distribution are discussed. A few cantilever and counterfort type retaining walls in reinforced concrete are designed with and without relief shelf and their costs are compared to show the economy in providing a relief shelf. It is clearly shown that a cantilever wall with a single relief shelf will be more economical than a counterfort wall of the same height.

5] **Prof. Shilpi Bhuniyan, Ms. Bhagyashree Girme , Mr. Bilal Lambe and Mr. Aditya Agrawal** stated that 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:- Displacement of shelf reduces as the width of shelf increases at a particular location and Self-weight of retaining wall with shelf increases due to which stability force increases and retaining wall become more stable.

6] **Umit Gokkus and Yesim Tuskan** given that A numerical study is conducted to investigate the effect of the number of shelves; shelf and wall stem rigidity and shelf horizontal location on the resulted lateral earth pressure distribution. According to the analysis it was found that the shelves have a significant effect on the distribution of the earth pressure. The numerical results indicate that the presence of a relief shelf behind the wall would result in a reduction of the earth pressure and also results show that shelf inclusions have positive role as pressure detractive for cantilever retaining walls in earthquake areas.

7] **Dharshan K, Keerthi Gowda B S** represented a study of cantilever earth retaining wall of 4m height is considered to analysis for its optimum parameters. Many limitations are there while designing a cantilever earth retaining wall for its optimum characteristics by manual approach. Such as, iterative process during analysis and usage of complex equations in design step. A new structural engineer has to face many decision making situations to design an optimum cantilever earth retaining wall. This is ticklish and time consuming work. Hence, here an attempt is made to analyze cantilever earth retaining wall with and without pressure relief shelf by using commercially available finite element packages (SAP-2000). Results are much adoptable than manual analysis. Hence analysis and design of cantilever earth retaining wall by using finite element software packages are easier and effective compared to manual approach. An application of pressure relief shelf optimizes the parameters of cantilever earth retaining wall about 35 %. Deciding the optimum position of pressure relief shelf by manual approach is highly complicated and tedious job, here it is achieved by using finite element software package effectively.

8] **Tonne V. R, Mohite P. M** concluded that Cantilever retaining wall with one relief shelf is economical up to height of 10 m above that counterfort retaining wall with relief shelf is useful. In this paper analysis and design of counterfort retaining wall with one relief shelf is done for various positions of relief shelf. These results are studied to get minimum earth pressure, more stability and minimum moment in each component of retaining wall. The optimization of counterfort retaining wall is done to get minimum size of retaining wall. Due to this optimization extra formation width is available in hilly areas and excessive cutting is avoided thereby construction cost reduces and also it results in reduction in cross-section of retaining wall by 49.86% in 10 m, 49.84% in 12 m and 43.75% in 15 m height of wall.

III. LOADS

DEAD LOAD

The dead load carried by the member would consist of the portion of the weight of the structure which is supported wholly or in part by the member including its own weight. The following unit weights of the materials had been used in determining loads, unless the unit weights have been determined by actual weighing of representative samples of the material in question, in which case the actual weights as thus determined has been used.

TABLE 3.1: UNIT WEIGHT OF MATERIAL

	MATERIAL	UNIT WEIGHT (KN/M3)
I	Concrete (asphalt)	22
II	Concrete (cement-reinforced)	25
III	Earth (compacted)	20
IV	Steel (Rolled or Cast)	78
V	Water	10

EARTH PRESSURE

The structure to retain earth fills should be proportional to withstand pressure calculated in accordance with Coulomb's theory.

Height of earth retained 'H'= Clear height + Bottom slab thickness

PROBLEM STATEMENT AND MODELLING

The following retaining wall was studied in the study:-

Height of Retaining Wall = 6m

Safe bearing capacity of soil = $10t/m^3$

Angle of friction of soil = 30^o

6 models were developed in STAAD Pro with shelf provided at every 1 m from the bottom slab is 5 models and 1 model was developed without shelf. Both the ends of base slab were fixed for analysis.

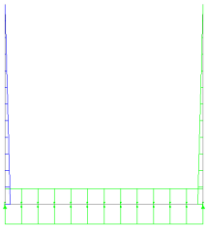


FIG.(A)

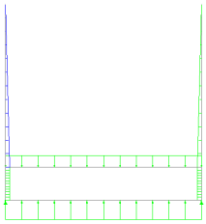


FIG. (B)

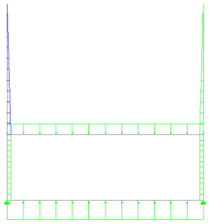


FIG. (C)

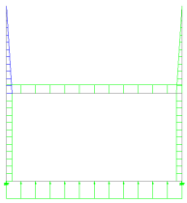


FIG. (D)

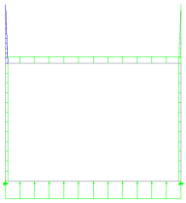


FIG. (E)

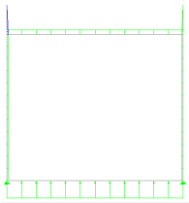


FIG. (F)

FIG. (A) - : U TYPE RW WITHOUT SHELF

FIG. (B) - : U TYPE RW WITH SHELF 1MTR FROM BASE SLAB

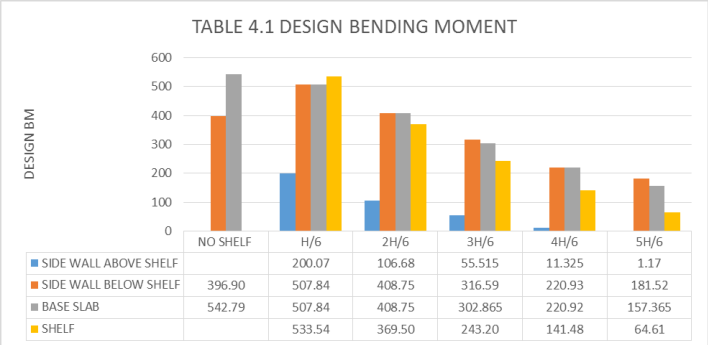
FIG. (C) - : U TYPE RW WITH SHELF 2MTR FROM BASE SLAB

FIG. (D) - : U TYPE RW WITH SHELF 3MTR FROM BASE SLAB

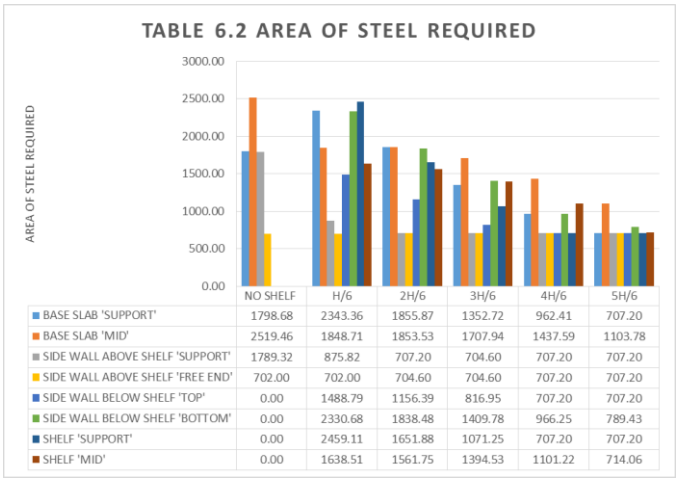
FIG. (E) - : U TYPE RW WITH SHELF 4MTR FROM BASE SLAB

FIG. (F) - : U TYPE RW WITH SHELF 5MTR FROM BASE SLAB

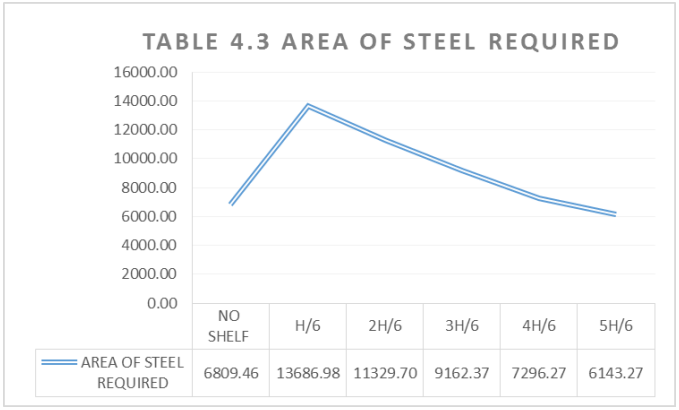
IV. RESULTS



	NO SHELF	H/6	2H/6	3H/6	4H/6	5H/6
SIDE WALL ABOVE SHELF		200.07	106.68	55.515	11.325	1.17
SIDE WALL BELOW SHELF	396.90	507.84	408.75	316.59	220.93	181.52
BASE SLAB	542.79	507.84	408.75	302.865	220.92	157.365
SHELF		533.54	369.50	243.20	141.48	64.61



	NO SHELF	H/6	2H/6	3H/6	4H/6	5H/6
BASE SLAB 'SUPPORT'	1798.68	2343.36	1855.87	1352.72	962.41	707.20
BASE SLAB 'MID'	2519.46	1848.71	1853.53	1707.94	1437.59	1103.78
SIDE WALL ABOVE SHELF 'SUPPORT'	1789.32	875.82	707.20	704.60	707.20	707.20
SIDE WALL ABOVE SHELF 'FREE END'	702.00	702.00	704.60	704.60	707.20	707.20
SIDE WALL BELOW SHELF 'TOP'	0.00	1488.79	1156.39	816.95	707.20	707.20
SIDE WALL BELOW SHELF 'BOTTOM'	0.00	2330.68	1838.48	1409.78	966.25	789.43
SHELF 'SUPPORT'	0.00	2459.11	1651.88	1071.25	707.20	707.20
SHELF 'MID'	0.00	1638.51	1561.75	1394.53	1101.22	714.06



	NO SHELF	H/6	2H/6	3H/6	4H/6	5H/6
AREA OF STEEL REQUIRED	6809.46	13686.98	11329.70	9162.37	7296.27	6143.27

V.CONCLUSIONS

The following conclusions were drawn from the above the study:-

1. From GRAPH 1 it is found that the bending moment for side wall when the shelf is provided at 5H/6 from bottom (i.e. 1 m from finished top level) shows a reduction of 54.26 % from bending moment of retaining wall without shelf.
2. From GRAPH 1 it is found that the bending moment for base slab when the shelf is provided at 5H/6 from bottom (i.e. 1 m from finished top level) shows an increment of 71% from bending moment of retaining wall without shelf.
3. From GRAPH 2 it is found that the area required for base slab when the shelf is provided at 5H/6 from bottom (i.e. 1 m from finished top level) shows a reduction of 60.68% from area required of retaining wall without shelf.

4. From GRAPH 2 it is found that the area required for side wall when the shelf is provided at 5H/6 from bottom (i.e. 1 m from finished top level) shows a reduction of 60.47% from area required of retaining wall without shelf.
5. From GRAPH 3, it is found that the area of steel required per meter of retaining wall is minimum when shelf is provided at a distance of 5H/6 from the bottom slab (i.e. 1m from the finished top level).

Thus it can be concluded that for optimum result shelf should be provided at 5H/6 from the bottom (i.e.1 m from the finished top level)

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