Optimize Positioning of Relief Shelf in Cantilever Retaining Wall

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Abstract

The Concept of providing pressure relief shelves on the backfill side of a retaining wall reduces the total earth pressure on the wall, due to which it reduces the thickness of the wall and ultimately gives more economical design. In the present study an attempt is made to analyse the cantilever retaining wall with pressure relief shelf by using finite element package (SAP-2000). Springs are assigned by discretising the model to simulate soil properties. The model is validated from the standard book. Using SAP-2000 optimized position of relief shelf is concluded for the single shelf cantilever retaining wall by considering top displacement of the wall and the maximum bending moment in stem and shelf, using those results further studies can be made for economy of the structure.

Keyword- Cantilever Retaining Wall, Pressure Relief Shelf, SAP-2000, Depth Ratio (h/H)

I. INTRODUCTION

A Retaining wall is constructed to sustain the lateral earth pressure of backfill behind it. Retaining structures may be of different type such as cantilever retaining wall, counterfort retaining wall, buttress retaining walls, etc. A retaining wall with relief shelves is one of the special types of earth retaining structure. High cantilever type of retaining wall can be economical constructed by providing the relief shelves on the backfill side of the wall.

Chaudhari et al (1973) tells about the decreased in the total lateral earth pressure on the cantilever retaining wall which was the first study on reduction of earth pressure. Patil S. S. (2015) has summarized to reduce the stresses on the retaining face of the cantilever retaining wall. Chougule, A.C. (2017) has conducted a thorough analysis of the design measures taken of single and double shelves and without shelves. Lateral earth pressure is zero at the top of the wall and increases linearly to a maximum value at the lowest point. The total earth pressure on the wall acts at one-third from the lowest point.

II. MODELLING

A. General Model Procedure

The model for relief shelf cantilever retaining wall using thick shell element is modelled using SAP-2000. All the models are having the same data and c/s dimensions except the position of pressure relief shelf (depth ratio) which are varying in each case for parametric study. Dimensional properties for different types of models are as shown in Table 1. Properties of soil like dry density, modulus of elasticity, angle of internal friction, poisson's ratio, safe bearing capacity of soil and properties of concrete like grade of concrete are as shown in Table 2

Structural Elements	*Dimensions*
Height of Retaining Wall	*8.0 m*
Width of Toe Slab	*2.0 m*
Width of Heel Slab	*3.0 m*
Thickness of stem (t_s)	*0.5 m*
Thickness of footing slab	*0.8 m*
Width of Relief Shelf	*2.0 m*
Thickness of Relief Shelf	*0.4 m*
Depth ratio (h/H)	*0.1 to 0.8*

Table 1: Geometry of Retaining Wall

Property	*Soil*	*Retaining Wall*
Density	*20 kN/m^3*	*25 kN/m^3*
Modulus of Elasticity	*20 N/mm^2*	*25000 N/mm^2*
Angle of internal friction	*30^o*	*-*
Safe bearing capacity	*180 kN/m3*	*-*

Poisson's Ratio	*0.5*	*0.2*

Table 2: Material Properties

Figure 1 and Figure 2 shows the sketch of modelled relief shelf cantilever retaining wall using thick shell element in SAP-2000.

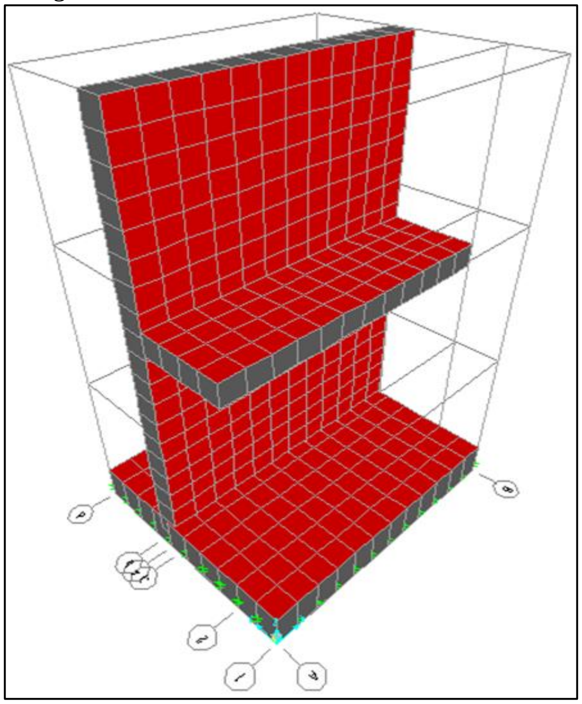

Fig. 1: Schematic 3D Model of Cantilever retaining wall with shelf

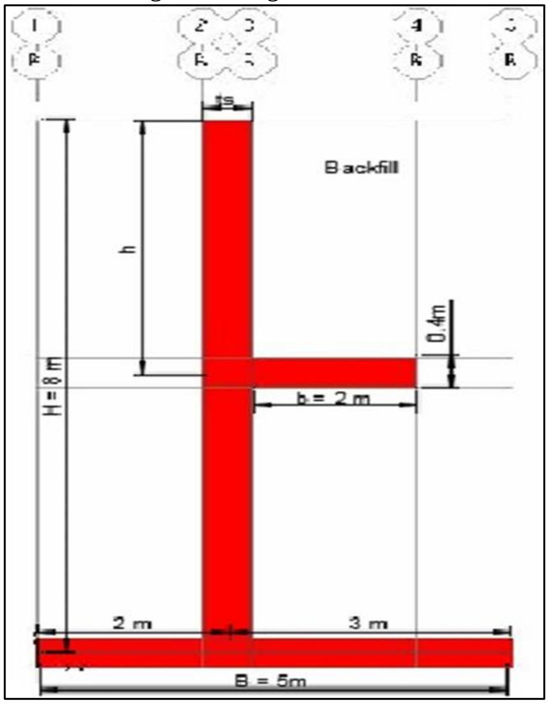

Fig. 2: Dimensions of Cantilever retaining wall with shelf

III. RESULTS

The result for maximum top deflection and the maximum moment in the stem and relief shelf obtained from SAP-2000 after changing the various position of pressure relief shelf has been summarised in Table 3.

Shelf Position depth ratio (h/H)	*Displacement at top of wall (mm)*	*Mmax at wall (kN/m)*	*Mmax at shelf (kN/m)*
0.0	*102.93*	*862.42*	*0.05*
0.1	*81.36*	*741.61*	*61.30*
0.2	*72.90*	*691.28*	*119.18*
0.3	*72.52*	*674.50*	*163.80*
0.4	*76.18*	*671.14*	*205.07*
0.5	*80.85*	*674.50*	*226.28*
0.6	*83.49*	*647.65*	*294.16*
0.7	*86.15*	*617.45*	*318.71*

Table 3: Displacement and Maximum Moment in wall and shelf

Above tables are plotted and analysed to have a clear picture of optimum depth ratio (h/H) that must be provided in order to achieve economy.

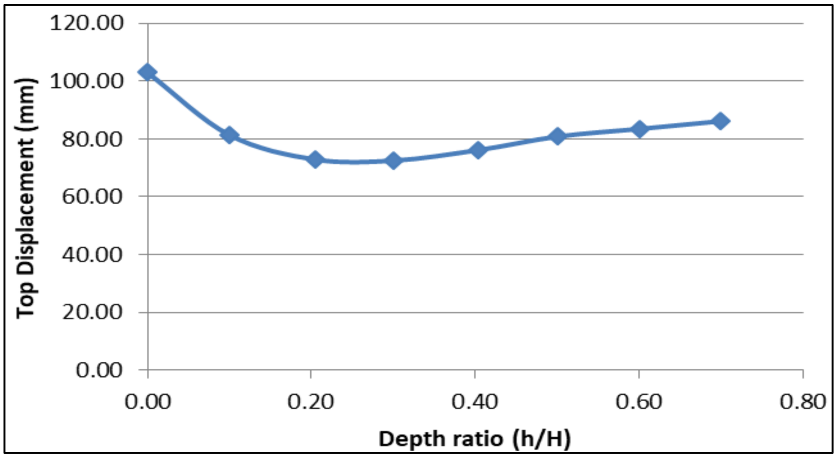

Fig. 3: Top Displacement vs Depth ratio for various position of shelf

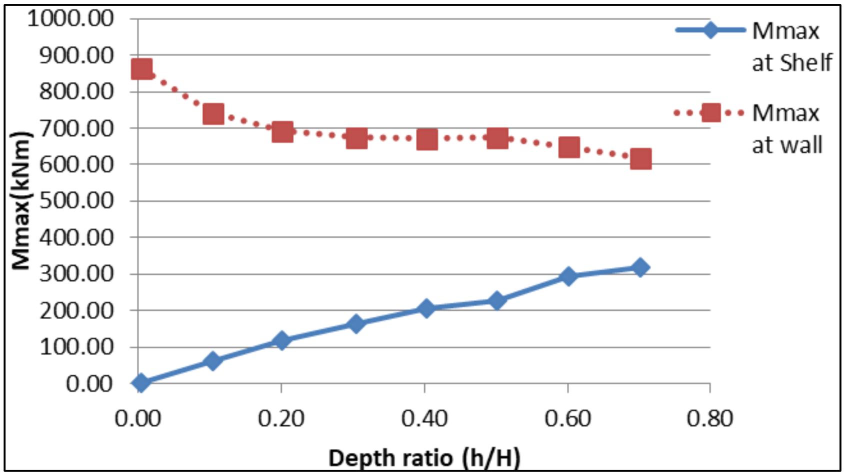

Fig. 4: Maximum Bending Moment on the wall and shelf vs Depth ratio

CONCLUSIONS

1) The top displacement of the cantilever pressure relief shelf retaining wall is found to be least at the depth ratio (h/H) of 0.3.
2) The maximum bending moment in the wall significantly decreases as the depth ratio (h/H) increases till depth ratio of 0.3 and beyond 0.3 the decrease in bending moment is comparatively less.
3) On the other hand the maximum moment on the pressure relief shelf increases linearly with the increase in depth ratio.
4) The optimized position of pressure relief shelf for least top wall displacement and appropriate bending moment on the wall and pressure relief shelf is found to be at depth ratio (h/H) of 0.3.

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