Parametric Study of Base of Cantilever Retaining Wall

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Abstract— In this paper, discrete design optimization of a cantilever retaining wall has been submitted associated with a detailed parametric study of the wall without surcharge. In optimal design, the wall base width and heel to toe ratio are treated as the objective function. Through design algorithm, the optimal design variables (base width, toe width, thickness of base slab and thickness of heel) yielded minimum structural weight of the wall and satisfied stability conditions have been determined for different heights. At the end, a detail parametric study searching the effect of change of soil parameters on the retaining wall design has been conducted with 3 heights for different values of percentage distribution of base width ; constant values of the angle of internal friction(Φ=30), and three values of wall heights. The obtained results from optimization analyses indicate that change of the percentage of distribution base width from 50-75 % most of the parameter are satisfied at 50% of percentage distribution are observed to be safe.

Keywords: Cantilever retaining wall Structural optimization, percentage distribution of base width, Discrete design optimization

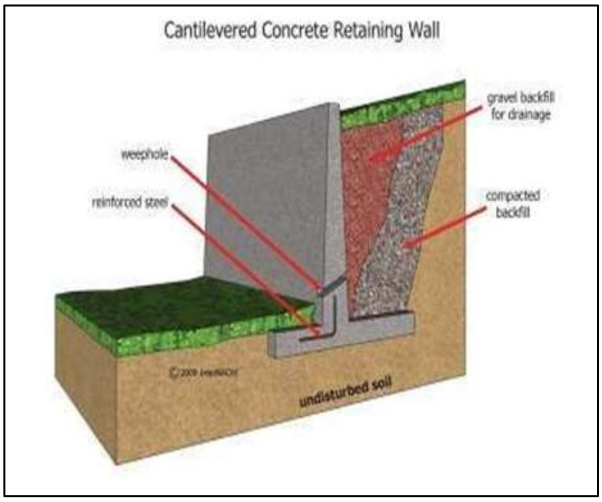
I. Introduction

In geotechnical engineering, the retaining walls are employed to resist lateral soil load in case of constructing works like an excavation, slopes, railway or highway as lateral support. In conventional design of a retaining wall, stability conditions like sliding and overturning are checked by using selected wall dimensions, firstly. If selected wall dimensions do not ensure stability conditions, this trial and error process is continued, till satisfying stability conditions.

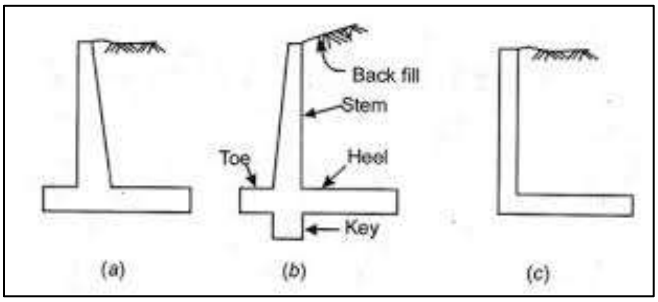
Even though safe wall dimensions have been obtained in plenty of time, it is not certain that obtained wall design is the most economic among all possible solutions. On the other hand, conditions of worksite like ground water level, soil height to be supported laterally or intended use of structure and soil properties such as bearing capacity or behavior of settlement under loads of soil should be considered in case of design. Existing of all mentioned situations in wall design with reasonable cost make this design a challenging engineering problem with many unknowns. Retaining walls are structures designed to restrain soil to a slope that it would not naturally keep to (typically a steep, near-vertical or vertical slope). 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. Cantilever Retaining Walls

A cantilever retaining wall is one that consists of a wall which is connected to foundation. A cantilever wall holds back a significant amount of soil, so it must be well engineered. They are the most common type used as retaining walls. Cantilever wall rest on a slab foundation.



Cantilever retaining walls are constructed of reinforced concrete. They consist of a relatively thin *stem* and a *base slab*. The base is also divided into two parts, the *heel* and *toe*. The heel is the part of the base under the backfill. The toe is the other part of the base .Use much less concrete than monolithic gravity walls, but require more design and careful construction. Generally economical up to about 25 ft. in height .Can be precast in a factory or formed on site . There are two type of cantilever retaining wall l-cantilever and t-cantilever



III. Literature Reviews

A.A.R.Bagban,2015 reviews that Stepped cantilever Retaining wall are economically best suited for wall heights from 11.0 M to 15.0 M. this is proving to be better alternative for large wall heights as more than 11.0 M.

Faradjollah Askari, 2017 disscused that the geometric dimensions of the wall affect its safety factors and the active pressure on the wall.

The length of the heel at the base of the wall affects the magnitude and direction of the active pressure on the retaining wall.

Dr. G. D. Awachat,2019 concluded that The overturning moment get reduced due to provision of relief shelves. The concrete and steel is reduced by providing relief shelve to the cantilever retaining wall.

Chetan Sharma observed that the calculated factor of safety against sliding is increasing when the density of back fill material is decreased. It shows that the resultant horizontal force affects the factor of safety against sliding and its allowable resistance.

G. L. Sivakumar Babu observed that If the backfill material is well engineered and if the coefficient of variation is less, then a considerable amount of savings in concrete can be achieved.

Robert W. Day,in 2011 concluded that the cantilevered retaining wall must have an adequate factor of safety for failure as a result of sliding and overturning, and must have a footing bearing pressure less than the allowable bearing pressure

DR. Dhamdhere & DR. V R Rathi has vastly covered the detailed information about Permanent displacement of retaining structures are tolerable as long as the movement does not lead to unacceptable damage to the structures .

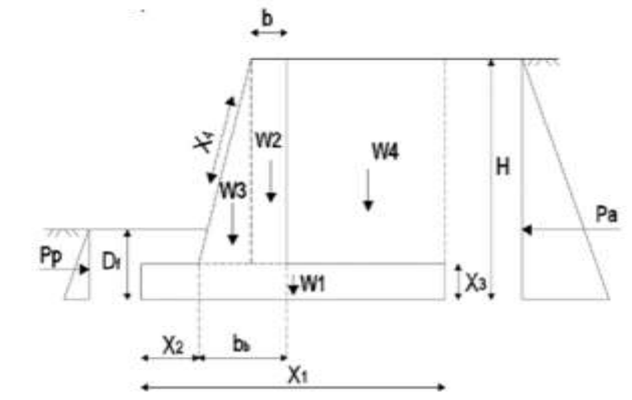


Fig. 1. Cantilever retaining wall and design variables.

Design parameters,

Height – 4 m

M-20 grade concrete & FE-415 steel

Assumption –

SBC – 160 KN/m2

Unit weight of soil (γs) = 16 KN/m2

Angle of repose (Φ) = 30o

Depth of foundation = q/γs (1- sinΦ/1+sinΦ)2

= 160/16 (1-sin30/1+sin30)2= 1.11 m

Total height = 4+1.25 = 5.25 m

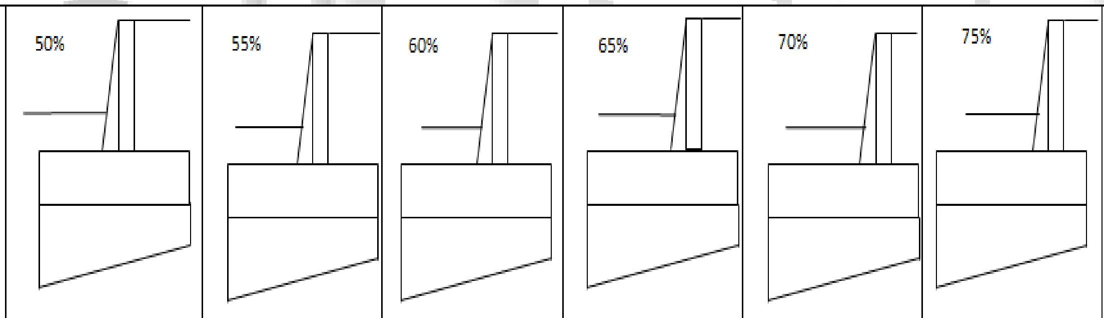
Sizes: B = H/2 = 5.25/2 = 2.6

Say 3 m.

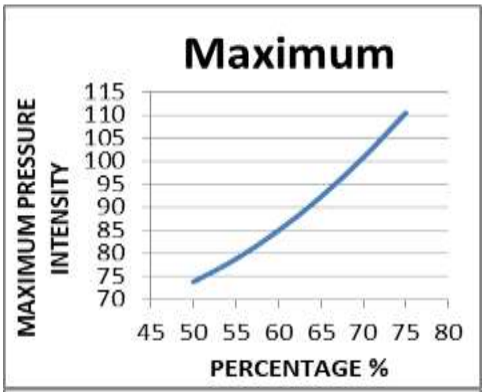
Thickness of wall and base slab = H/12 = 5250/12 = 437 mm

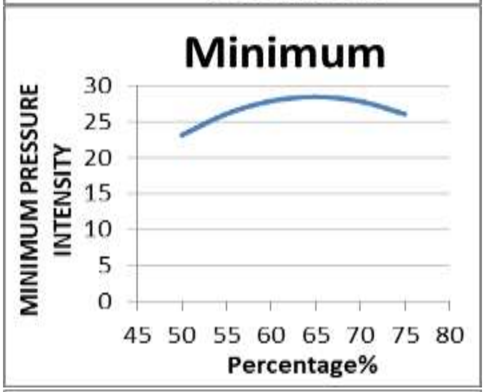
Say 450 mm

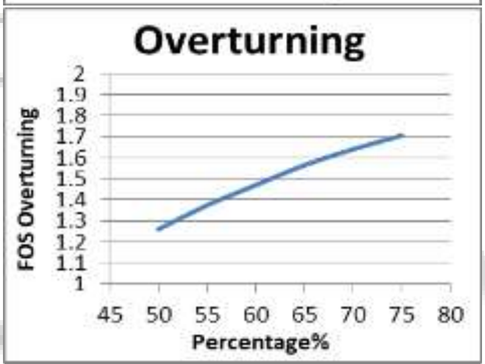
Ka = 1-sinΦ/1+sinΦ = 1-sin30/1+sin30 = 1/3

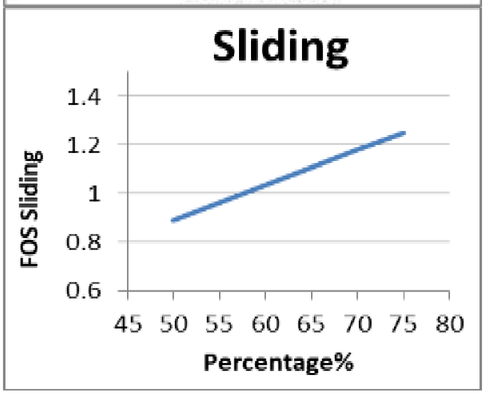


	50%	55%	60%	65%	70%	75%
Max	73.7841	78.7465	84.89688	92.235	100.76	110.47
Min	23.138	26.094	27.87	28.445	27.84	26.047
Pressure Distribution	50.65	52.65	57.06	62.79	72.92	84.423
Fos Over	1.206	1.374	1.47	1.565	1.641	1.706
Fos sliding	0.89	0.9628	1.036	1.108	1.181	1.25
Th of wall	197.66	197.66	197.66	197.66	197.66	197.66
Th of heel	149.912	158.544	[illegible]	174.97	182.86	190.469
Th of toe	124.635	114.04	102.582	89.97	75.939	60.197
Area index	411.8213	415.56	423.46	435.67	452.36	473.701









IV. CONCLUSION

1) When the percentage of the width of the base increases then maximum pressure also increases.
2) Pressure distribution should be low so as to have uniform pressure.
3) In the above table 50% of width of the base having lowest pressure distribution.
4) As the percentage distribution of width increases then minimum pressure increasae & after 65 % its start decreasing.

For stability :
1. Sliding – FOS >=1.4
(As per IS Code)
2. Overturning – FOS >= 1.2

5) according to our analysis as the percentage of width increases factor of safety aginst overturning increases & more safe value is obtained at 75 %
6) Similarly as the percentage of width increases factor of safety against sliding increases but we found unsafe thus we have to provide shear key.
7) Here, The minimum thickness value of heel is always observed at 50% of the width of base
8) The minimum thickness value of toe is always observed at 75% of the width of the 9. When Area index is minimum then at 50% structure is more economical & its observed

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