Proceedings of Indian Geotechnical Conference
December 15-17,2011, Kochi (Paper No. K-056)

ROLE OF SHEAR KEYS IN CANTILEVER RETAINING WALL

Nisha Sarath, Graduate Student, NITK,Surathkal,Mangalore, 575025, INDIA, nishasarath@yahoo.com
R.Shivashankar, Professor, NITK, Surathkal,Mangalore, 575025, INDIA, shivashankar.surathkal@gmail.com
A.U.Ravi Shankar, Professor, NITK, Surathkal,Mangalore, 575025, INDIA, aurshankar@yahoo.com

ABSTRACT: In this paper, the earth pressure distribution generated behind a retaining wall supporting sand, is estimated by the finite element method (using the finite element Plaxis program) and compared with those obtained from classical earth pressure theories like the ones proposed by Rankine (1857) and Coulomb (1776). In this analysis the behaviour of soil is assumed to be elasto-plastic with Mohr-Coulomb failure criterion. The concrete wall is represented by linear elastic model. The performance of the cantilever retaining wall with the shear key in various positions is also being studied analytically. The active and passive lateral earth pressures acting on the wall stem, obtained from the three approaches, are compared and discussed. Good agreement is found especially in the case of active earth pressures.

INTRODUCTION

Retaining walls are structures that are used to retain earth (or any other material) in a position where the ground level changes abruptly. They can be of many types such as gravity wall, cantilever wall, counterfort wall and buttress wall among others.

.

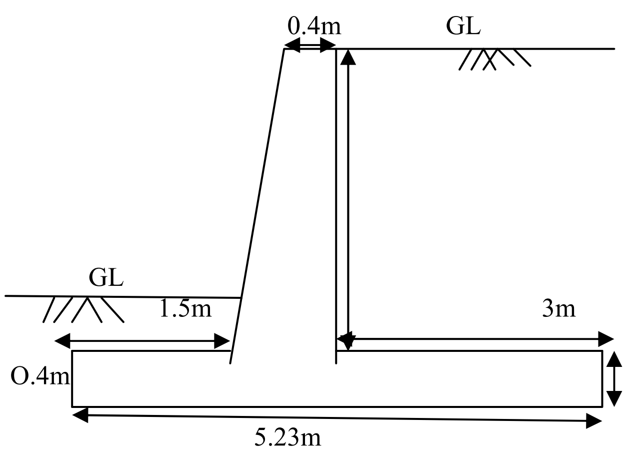

Figure 1. Dimensions of the Cantilever Retaining Wall

Shear Key in Retaining Wall

Since the cantilevered retaining wall is by far the most common type of retaining wall used, it is important to achieve as much efficiency in its design as possible. In general, the width (B) of the footing should range from 0.40 to 0.60 times the height (H) of the wall above the top of the footing. Retaining walls must provide adequate resistance against sliding. The resisting forces against sliding are mainly due to friction of wall base and the foundation materials and partly due to the passive earth pressure of the soil which may develop in front of the retaining wall as the wall tends to slide towards it.

If the wall is found to be unsafe against sliding, shear key below the base is provided. Such a key develops passive pressure which resists completely the sliding tendency of the wall. Safety factor may be defined as the ratio of resisting forces or moments to the forces or moments which tend to instabilize the wall. To insure proper functioning of the wall during its lifetime, adequate safety factors should be adopted. The safety factor against sliding should be at least 1.5 for cohesionless and about 2.0 for cohesive backfill. Where sufficient sliding stability is not possible—usually for walls with large H—a base key, has been used. There are different opinions on the best location for a key and on its value. It was common practice to put the key beneath the stem. This approach was convenient from the view of simply extending the stem reinforcement through the base and into the key.

In this paper, shear key has been considered in three locations. ie, Below heel, stem and toe. The dimension of the shear key considered are width of 0.5m and depth of 0.5m, 1m,1.5m and 2m.

Description of the Problem

A cantilever retaining wall with the dimension shown in the Figure 1 is being analysed..The finite element mesh is as shown in Figure 2, while the material properties are given in Tables 1 and 2.

In this paper, the earth pressure distribution generated behind a retaining wall supporting sand, is estimated by the finite element method (using the finite element Plaxis program) and compared with those obtained from classical earth pressure theories like the ones proposed by Rankine (1857) and Coulomb (1776). For Rankine's analysis five different cases are considered with Ø = 25°, 30°, 35°, 40° and 45°. For Coloumb's analysis each of this case with wall friction, δ = 0.5 Ø, 0.67Ø, 0.75Ø, Ø is considered. Finally finite element analysis is carried out using commercial software PLAXIS version 8.2 for all cases mentioned above.For all the cases retaining wall without shear key and with shear key at the heel, stem and toe are considered separately.

For the analysis, active case and passive case have been considered with loads of 100 KN and 400KN respectively.

Table 1 Properties of Concrete (Linear Elastic)

γ_{unsat} [kN/m³]	γ_{sat} [kN/m³]	k_x [m/day]	k_y [m/day]	E_{ref} [kN/m²]	ν -
24	24	0	0	3E7	0.15

Table 2 Properties of Soil (Mohr – Coulomb)

γ_{unsat} [kN/m³]	γ_{sat} [kN/m³]	k_x [m/day]	k_y [m/day]	E_{ref} [kN/m²]	ν -
16	18	0.1	0.1	40000	0.3

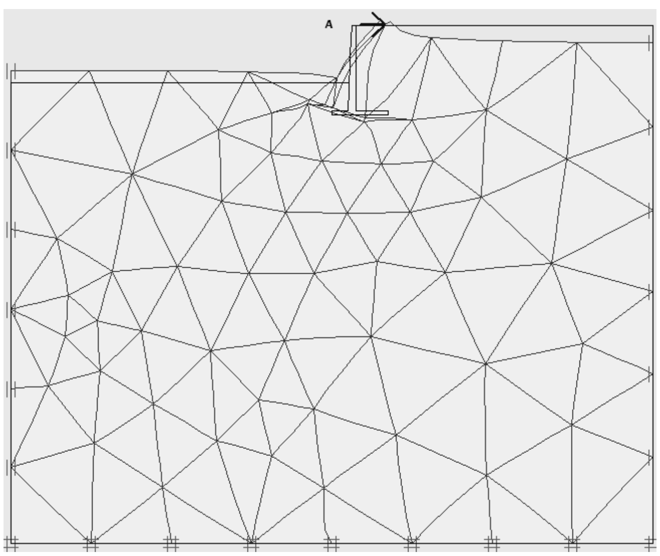

Figure 2. Deformed mesh for a Passive load of 400KN

Results without shear key

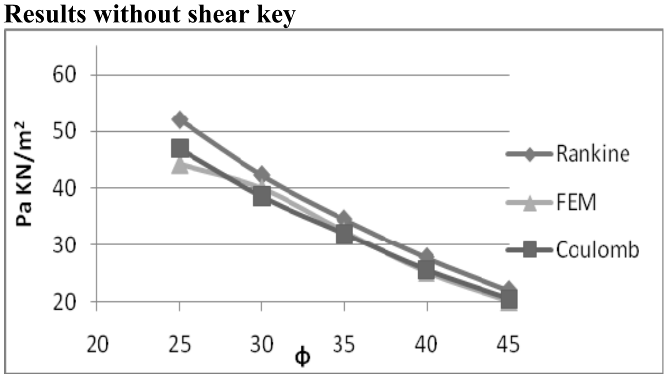

Figure 3. Maximum active earth pressure for δ = 0.5 Φ

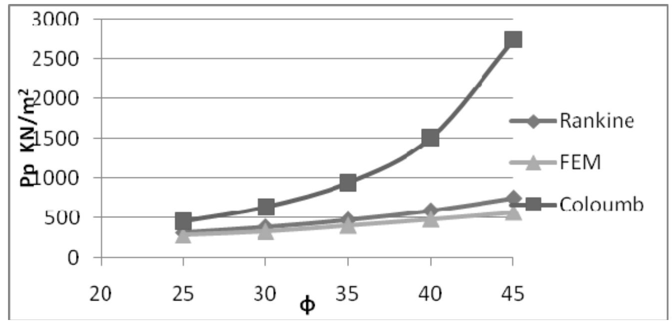

Figure 4. Maximum passive earth pressure for δ = 0.5Φ

Results with Shear Key

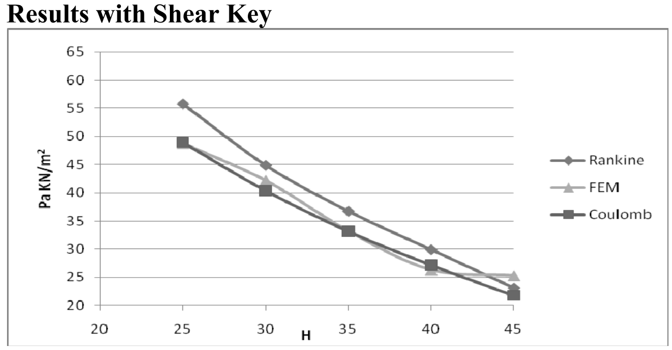

Figure 5. Pa max for δ = 0.67 Φ and Shear Key at Toe

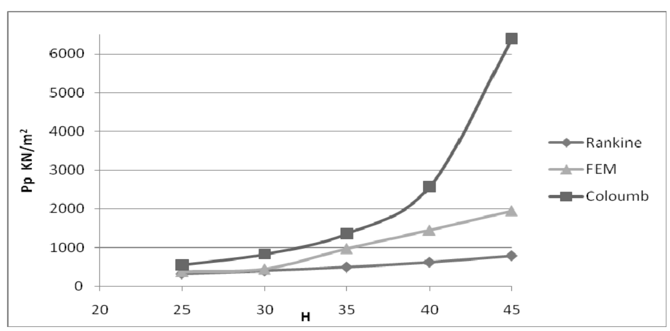

Figure 6. Pp max for δ = 0.67 Φ and Shear key at Toe

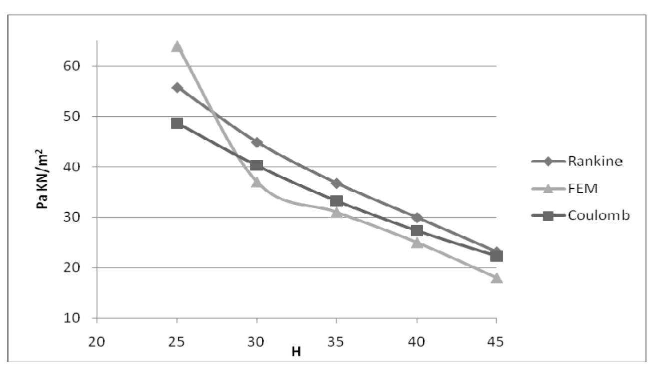

Figure 7. Pa max for δ = 0.75 Φ and Shear Key at Stem

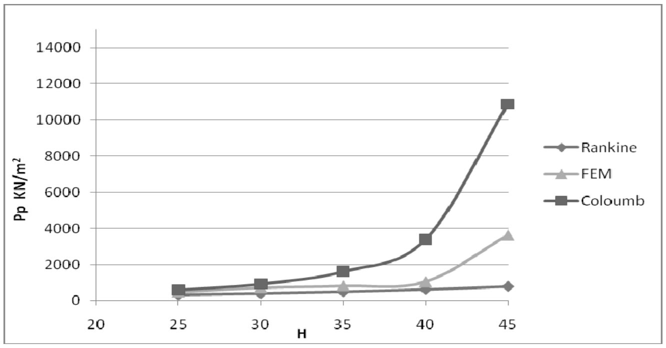

Figure 8. Pp max for δ = 0.75 Φ and Shear Key at Stem

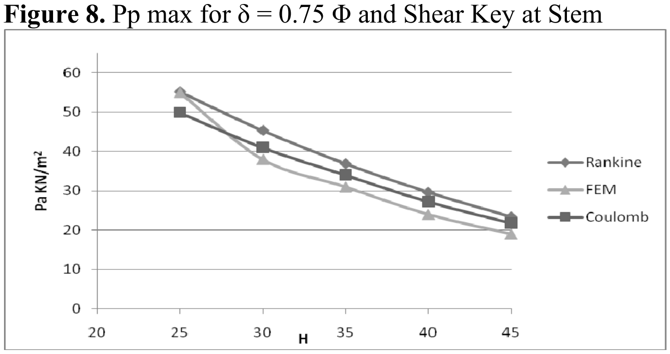

Figure 9. Pa max for δ = 0. 5 Φ and Shear Key at Heel

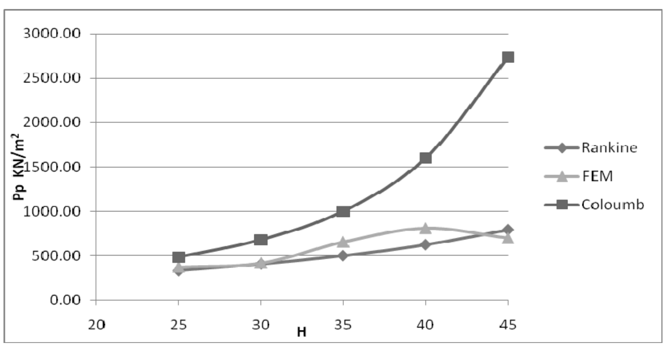

Figure 10. Pp max for δ = 0. 5 Φ and Shear Key at Heel

Below are the graphs showing depth of shear key v/s Factor of safety against sliding for different □.From the graphs it can be observed that factor of safety against sliding increases as the depth of the shear key increases.In any case depth of shear key should not be more than half the base width.

In order to have an idea on the quantity of material for shear key, graphs showing percentage increase of factor of safety v/s depth fo breadth ratio for various angle of friction has been drawn.

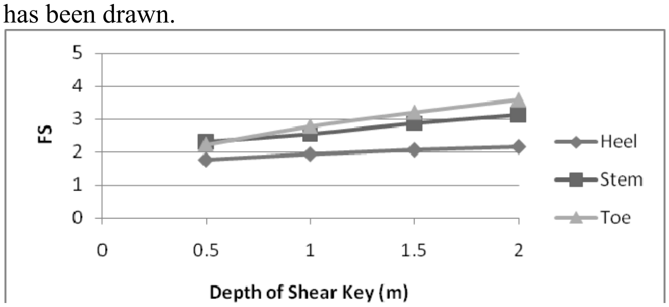

Figure 11.Factor of Safety for Φ = 25º and with shear key

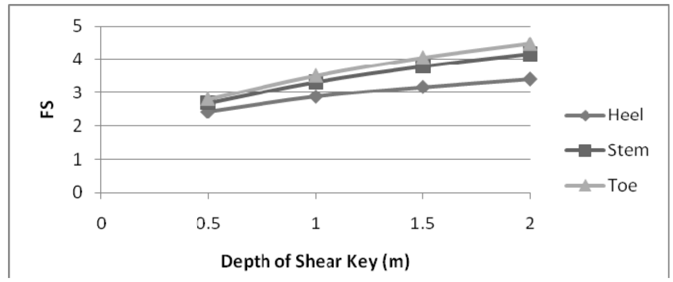

Figure 12. Factor of Safety for Φ = 30º and with shear key

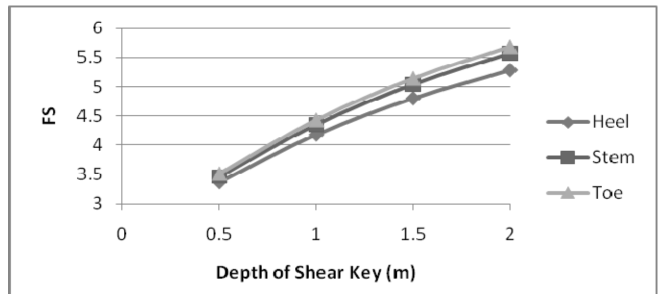

Figure 13. Factor of Safety for Φ = 35º and with shear key

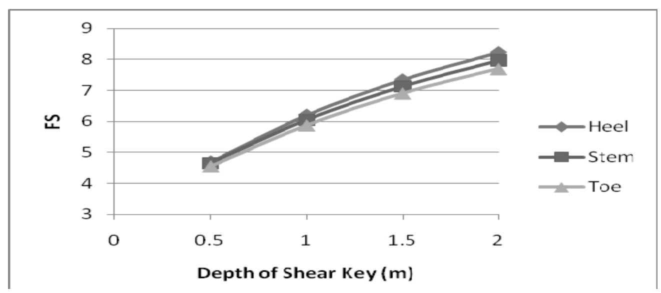

Figure 14 . Factor of Safety for Φ = 40º and with shear key

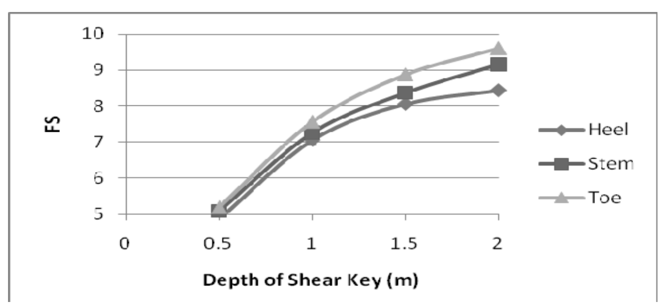

Figure 15 . Factor of Safety for Φ = 45º and with shear key

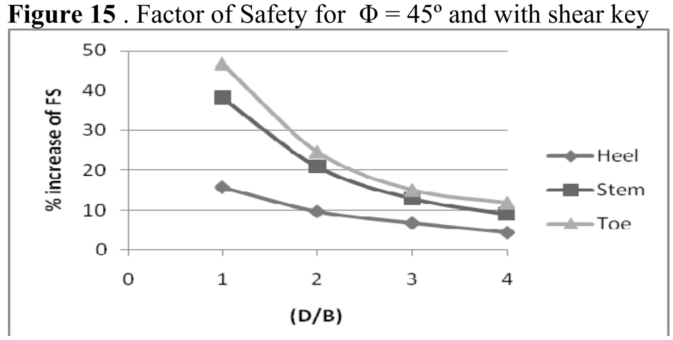

Fig 16. Percentage increase in FOS for Φ = 25º with shear key

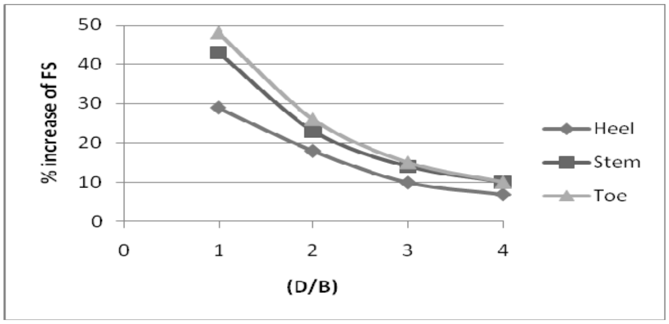

Fig 17.Percentage increase in FOS for Φ = 30º with shear key

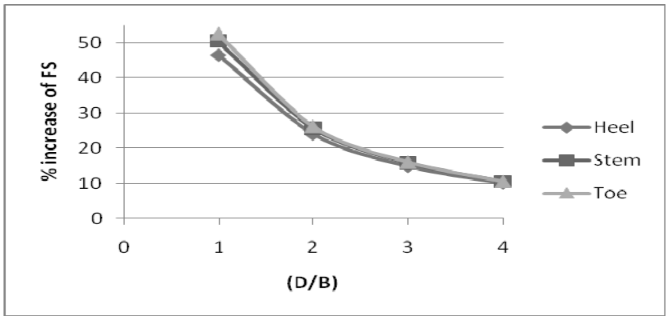

Fig 18. Percentage increase in FOS for Φ = 35º with shear key

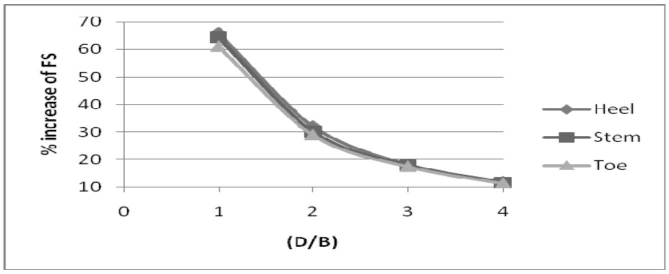

Fig 19. Percentage increase in FOS for Φ = 40º with shear key

CONCLUSIONS

From the above graphs and results following points can be recorded.

1. For active case, results obtained from finite element analysis are in good agreement with Rankine's and Coloumb's equation.
2. For passive case, results are close to Rankine's equation. The value of wall friction angle (when greater than zero), which is considered in case of Coloumb's equation, will not that affect the values of pressure distribution behind the retaining wall.
3. When comparing the location of shear key at heel, below the stem and toe, earth pressure is comparatively lesser in the case of heel, which in turn results in greater factor of safety against sliding.So the best location of shear key in a cantilever retaining wall is under the heel.
4. By increasing the depth of shear key from 0.5m to 2m, it shows an increase in factor of safety against sliding.
5. All the analyses performed in the study assume that the retaining wall founded on well treated or sound foundation in the present study. Therefore, ground movement only causes the minimum effect on wall deformation. In fact, study is needed to investigate the deformation behaviour of retaining wall on poor foundation.
6. All the analyses performed in this study assume that the retaining wall behaves in 2 – D plane strain condition. Therefore, it is necessary to perform the analyses in 3-D direction to verify the 2-D numerical analyses.

REFERENCES

1. Bentler,Joseph., Labuz,Joseph.,"Performance of a Cantilever Retaining Wall", Journal of Geotechnical and Geoenvironmental Engineering ASCE / DECEMBER 2007, Vol. 132, No. 8, pp. 1062–1070.
2. Iskander, G. M." Two dimensional simulation for the earth pressure of Point Load Acting Behind a Cantilever Wall " , Proceedings of the Thirteenth International Conference on Structural and Geotechnical Engineering, December 2009.
3. Plumey, Sylvain., Muttoni, Aurelio. , Vulliet, Laurent., Labiouse, Vincent., "Analytical and numerical analyses of the load-bearing capacity of retaining walls laterally supported at both ends ",International journal for numerical and analytical methods in geomechanics Int. J. Numer. Anal. Meth. Geomech. (2010)
4. Salman,F.A., Yousif, J., Al-Shakarchi , Husain, M. H. and Dunya, K.S. 2010, "Distribution of earth pressure behind retaining walls considering different approaches" International Journal of the Physical Sciences Vol. 5(9), pp. 1389-1400.
5. Sarath, Nisha., MTech Thesis, NITK, Surathkal, Mangalore, July 2011
6. Shekarian, S. , Ghanbar, A. , Makarchian, M. , "Earth Pressure on Retaining Walls with Reinforced Backfill", The 12th International Conference of International Association for Computer Methods and Advances in Geomechanics (IACMAG) 1-6 October, 2008
7. Yang, Kuo-Hsin., Liu, Chia-Nan., " Finite element analysis of earth pressures for narrow retaining walls", Journal of GeoEngineering, Vol. 2, No. 2, pp. 43-52, August 2007.