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Structural Analysis and Optimization of Retaining Walls Using ANSYS

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ABSTRACT:

A retaining wall is one of the main kinds of retaining structures. It is broadly utilized in assortment of circumstances, for example, highway designing, railway designing, bridge designing and water (irrigation) system designing. This project work targets fostering a connection between different boundary of retaining wall using ANSYS. The bending moment in toe and heel is less for retaining wall. The area of steel for toe and heel is less for retaining wall. The retaining wall with relieving platform is economical. By giving platform, the steadiness against sliding increments is significantly more. Furthermore, the factor of safety against sliding and overturning is practically twice in retaining wall. The retaining wall with relieving platform is substantially more secure against toppling and sliding.

Key words:- Retaining Wall, Optimization, Structure, Analysis, ANSYS.

Introduction:

Retaining walls are used to retain earth or other loose material. The outline design of earth retaining wall involves the choice of wall, while detailed design concerns with the numerical calculation necessary to allow for safe chosen wall. However, wall sections forms a crucial part of the overall design process and hence should be given much greater attention. This Project focuses on Structural analysis and Optimization of Retaining Walls using ANSYS by detailed numerical calculation and analysis using ANSYS software and comparing it with cantilever retaining wall and calculating and comparing results of both manually and in ANSYS software. This comparative design procedure should lead to economics of selection as a more informed comparison of alternative retaining wall types can be made.

ANSYS software helps in solving complex structural engineering problems with Finite Element Analysis (FEA) simulation software for implicit structural engineering problems and makes better, faster design decisions With finite element analysis (FEA) tools available in the suite, we can customize and Automate solutions for structural mechanics problems. ANSYS Structural analysis software is used throughout the industry to enable engineers to optimize their product designs means specialized service that requires engineering knowledge so as to reduce weight of the product and still enhances its strength and reduce the costs of physical testing.

Retaining walls are usually built to hold back soil mass. However, retaining walls can also be constructed for aesthetic landscaping purposes. Construction of a retaining wall is done to hold back the soil that lies behind it. Protection against slope-facing slope ruptures in cuts and fills, as well as from rolling down, is provided by a steep-facing slope of an earth mass. Buildings are toppled and slid as a result of the debris being trapped. Although self-weight plays an important role in retaining wall research and design, it is overshadowed by lateral ground pressure. Internal friction, cohesive strength of retained material, and movement of stems all influence lateral earth pressure behind the wall. A triangle pattern may be seen, with the lowest concentrations at the top & highest concentrations at the bottom of the wall. If not treated appropriately, the ground pressure might force the wall ahead or overturn it. Retaining walls are met and built in a variety of engineering sectors, including highways, ports, dams, subways, railways, tunnels, mines, and military defences.

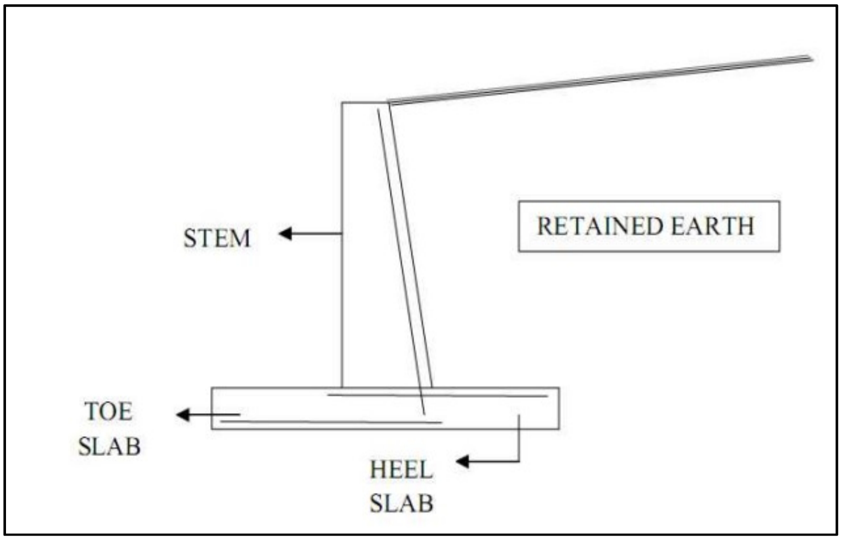

Fig. 1 Cantilever Retaining Wall

Literature Review:

Earlier retaining walls were considered as rigid structures which gives stability by its heavy weight. Charles Augustine de Coulomb (1776) [1] provided a method to determine earth pressure in which he considered the soil behind wall is whole instead of as an element in soil & it is therefore useful to assume that if the wall moved forward slightly a rupture plane would develop somewhere between the wall and backfill.

Donkada et. al. [2], in establishing knowledge of ideal solutions for reinforced concrete retaining walls, namely cantilever and counterfort relieving platforms for these three kinds of reinforced concrete structures. discovered that. Based on parametric investigations, heuristic principles for wall-size proportioning were established using genetic algorithms. To figure out which design option was best for a certain height, the best cost estimates for different types of retaining walls were compared. Retaining walls with relief platforms, a new idea in India was also mentioned.

Patil et. al. [3], the most significant retaining structure is a retaining wall It is widely employed in a wide range of engineering disciplines, including highways, trains, bridges, and irrigation. Stemmed concrete retaining walls are cast into the foundation slab of concrete construction and have a vertical or inclining shaft. A maximum height of 6 meters is deemed appropriate for them. Investigation of the wall's propensity to move forward under lateral earth pressure and provision of the safety factor 1.5 against sliding are both required.

Patil et. al. [4] It is necessary to design and construct retaining walls when the desired elevation change is larger than the soil's angle of repose. Retaining walls must be designed and placed with gravity in mind. A wall's ability to withstand lateral pressure from the ground is governed by its internal friction angle, its holding capacity, and the movement of its supporting structure. There are several examples of retaining walls that are 7 to 9 meters high. As a result, we'll take these heights into account for various counter-fort spacings in the absence of cohesive soil.

TamadherAbood et. al. [5], When there is a sudden shift in ground elevation, retaining structures may be used to keep back loose soil or other material. To prevent the structure from being overturned or slid, the backfill or retained material pushes against the structure. Most often, cantilever retaining walls are utilized for walls that are 3 to 6 meters high.

Inder Kumar et. al. [6], researchers discovered a study of the behavior and optimum construction of concrete dam counterfort retaining and gravity walls. Concrete and steel volumes are used in cost analysis to compare each wall design. It is decided that the option by lowest cost approximation is optimal design explanation after a comparison analysis.

Prof.SaritaSingla et. al. [7], When developing property, one often encounters the issue of producing a variation in topography elevation across an arbitrary horizontal distance. Slopes may be created, or retaining walls can be built, to accomplish this. It is a common practice for retaining walls to be built to hold back soil or other materials which are unable to stand on their own.

YashChaliawala et. al. [8], Two separate kinds of reinforced concrete walls, cantilever & counterfort retaining walls, have been analyzed for their behavior& optimal construction. The concrete and steel volume used in every ideal wall design for a certain height is used to determine the cost. The most cost-effective design option is selected from among the alternatives.

C. Chougule, J. P. Patankar, P. A. Chougule [9] In this work, a detailed examination of reinforced concrete cantilever retaining walls with single, double, & no shelves is conducted. Analyses are carried out both manually and using the software. STAAD Pro V8i software is used for software analysis.

Hany F. Shehata [10] Use PLAXIS2D-AE.01 for retaining wall analysis in this research. The availability of shelves reduces active earth pressure in the entire system. A significant effect on earth pressure distribution was found to be caused by the shelves. This reduces the bending moments of the retaining structures, making them more stable. As a result of these shelves, the wall's maximum deflection and deformation are considerably decreased.

Liu Minnan, Liu Fuchen [11] An explanation of the difference between long and short relieving platforms is provided in this article, along with an example of how to calculate the earth pressure on each. As long as the relieving platform extends farther than the sliding plane, it is ideal to locate it in the center of the retaining wall.

V. B. Chauhan, S. M. Dasaka [12] An investigation of the disappointment of cantilever retaining wall with relief shelves in Hyderabad, India, is the focus of this study. For analysis of strong retaining walls, FLAC3D makes use of five relief shelves that are equally spaced along the wall and at various heights. To reduce stress on the relief shelf and stem of the wall, a broader relief shelf was found to be beneficial.

SaritaSingla, Er. Sakshi Gupta [13] Specifically, this study examines the behavior and best design for three different heights of reinforced concrete walls. More cost-effective and helpful than cantilever and counterfort wall retaining structures, the relieving platform wall retaining structure has emerged as the clear winner in this comparison.

UmitGokkus, YesimTuskan [14] Researchers in this research used a cantilever-type retention wall on soil with low cohesiveness to determine how much a relief shelf in the wall reduces total dynamic earth pressure, overturning moments at the wall's base, & their distribution.

Hitesh Rathi, Dr. G. N. Ronghe [15] FEA is used to calculate the cantilever wall with the pressure relief shelf in this study (SAP-2000). For each additional meter of depth, the pressure relief shelf's maximum moment increases linearly. The depth ratio (h/H) of 0.3 was determined to be the best location for the pressure relief shelf to minimize top wall displacement while maintaining the proper bending moment on the wall and the pressure relief shelf. D.R. Dhamdhere (2018) [16] has worked for an optimal solution. He has chosen optimal cost as the best solution. He fixed base width & other dimensions of the retaining wall then performed stability check and determined min & max bearing pressure & then accordingly designed all portions of the retaining wall. C. Sanjei (2015) [17] selected various retaining wall shapes by performing preliminary calculations. He conducted finite element analysis, for that he used PLAXIS. He considered two ways of construction first one is Backfilling after the wall construction and the other is backfilling parallel to wall construction. He generated a finite element model for his analysis. He selected three different shapes with constant height and cross-sectional area. He used the trial method to adopt a stable section as per BS 8002.

Yazdandoust et. al. [18] In tests of steel-strip reinforced soil retaining walls, it was revealed that the deformation mode under harmonic excitations was strongly directly proportional to the length of steel strip reinforcement employed.Xu et al. [19] studied shaking table & pseudo-static data, & showed that the M-O approach might greatly overstate horizontal ground pressure compared to observed values.Zhou et. al. [20] For reinforced soil bridge abutments, a chart set was provided. For reinforced soil assemblies, he found that vertical spacing of reinforcements had an impact on their capacity as stability. Static loading is a primary use of the LA technique for reinforced soil structures.

Design factors:

- Length of alleviating stage: It is held equivalent to the length of heel slab for simple investigation reason.
- Thickness of easing stage: It is thought of as a one fourth of the thickness of base slab.
- Relieving platform Location of: It is considered at the mid-level of the retaining wall.
- Friction Angle (ϕ): 35º
- Active earth pressure Coefficient (Ka): $\frac{1-\sin\emptyset}{1+\sin\emptyset}$ = 0.27
- Passive earth pressure Coefficient (Kp) : $\frac{1+\sin\emptyset}{1-\sin\emptyset}$= 3.69
- Foundation depth:Height or profundity of establishment going from 3m to 10m with timespan is thought of.
- Soil bearing capacity:SBC is going from 100KN/m3 to 200 KN/m3 with time frame KN/m^3
- Unit weight of soil (Ys): 18 KN/m^3 andUnit weight of cement: 25 KN/m^3
- Grade of cement: M25 and Grade of steel: Fe500

Results and Discussion:

The results obtained during analysis of this projrvt work are putforth in the next section. Theresults obtained using ANSYS were discussed in this section.

5.1 ANSYS APDL analysis results of cantilever retaining wall:

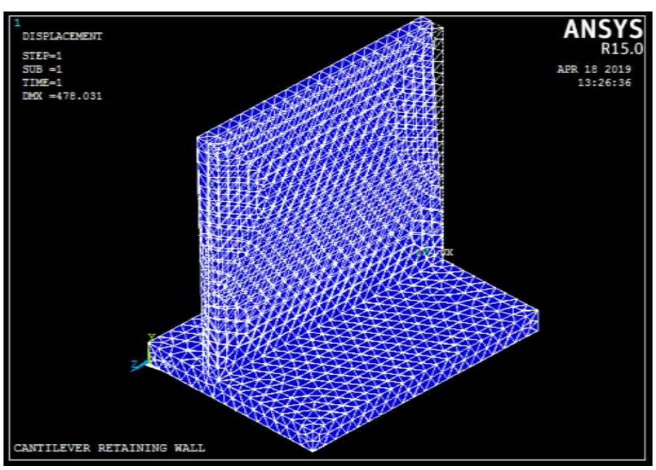

Fig. 2 Displacement of cantilever wall deformed and unreformed shape

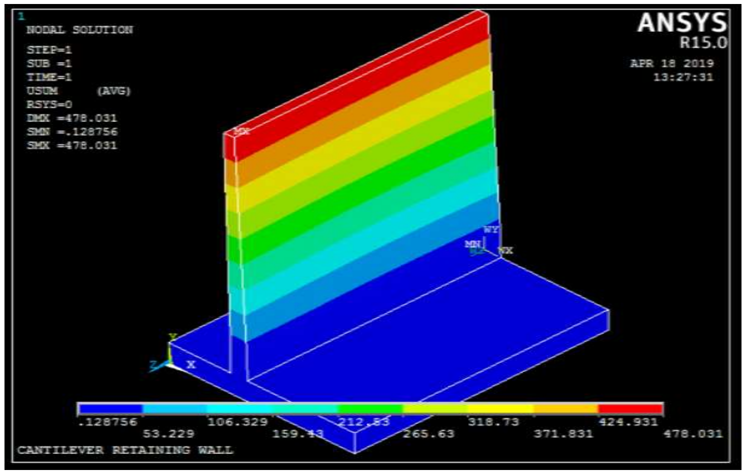

Fig. 3cantilever wall nodal solution displacement vector sum

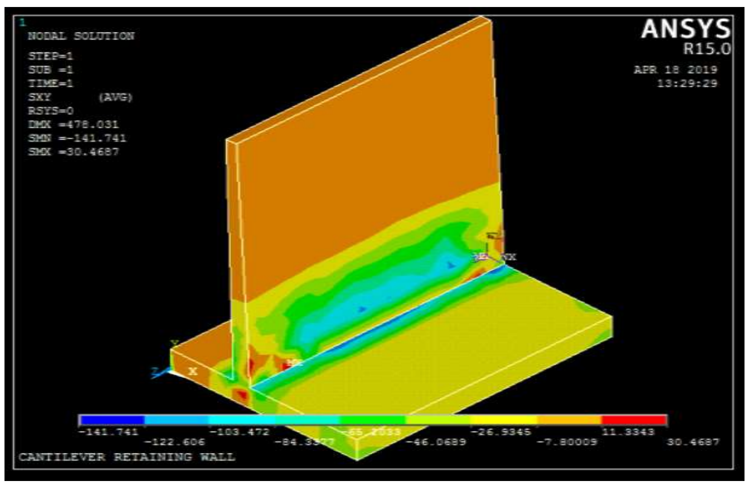

Fig. 4Shear stress in XY plane

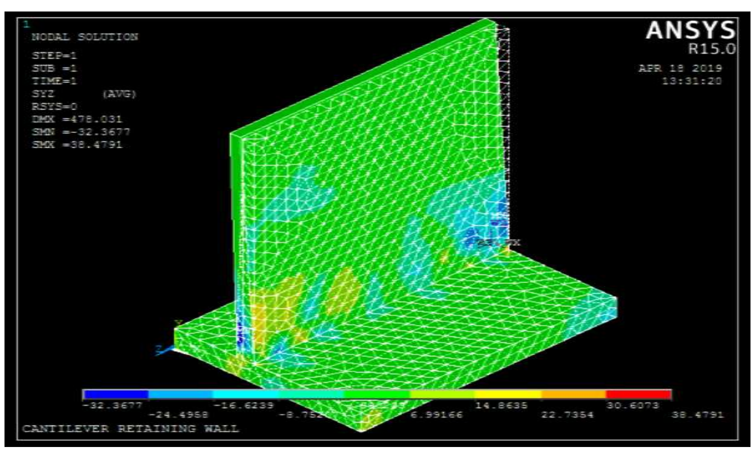

Fig. 5 Shear stress in YZ plane

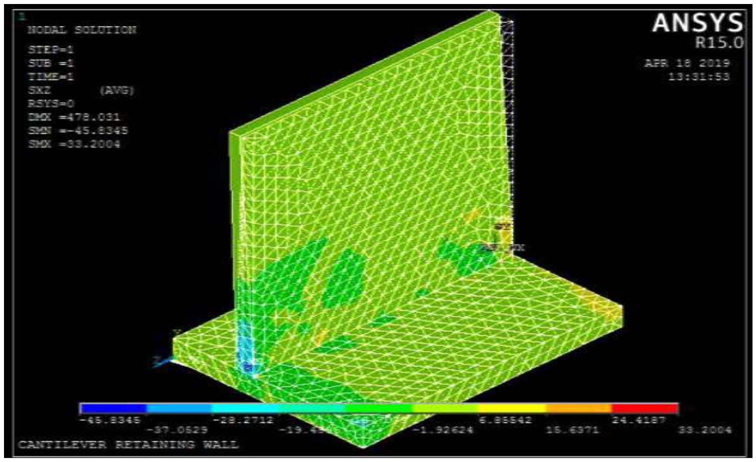

Fig. 6Shear stress in XZ plane

Conclusion:

A retaining wall is one of the main kinds of retaining structures. It is broadly utilized in assortment of circumstances, for example, highway designing, railway designing, bridge designing and water (irrigation) system designing. This project work targets fostering a connection between different boundary of retaining wall using ANSYS.

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