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Comparative Analysis of Cantilever Retaining Wall with and without Column

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***Abstract:** Retaining walls play a crucial role in civil engineering projects, providing stability to soil, preventing erosion, and mitigating landslides. To design and analyse these walls effectively, a profound understanding of soil mechanics, structural engineering principles, and various wall configurations is required. One notable configuration is the Cantilever Retaining Wall, which is known for its simplicity and effectiveness in resisting lateral earth pressures. However, for taller retaining walls, incorporating a column has shown potential in achieving greater cost-efficiency. This research aims to conduct a comprehensive analysis of cantilever retaining walls, comparing those with and without a column system. The study utilizes manual calculations, as well as software tools like STAAD Pro and Excel spreadsheets, for design optimization. Adherence to the guidelines specified in the Indian Standard IS 456:2000 for reinforced concrete structures ensures compliance with industry standards. The research involves a thorough examination and design of both the Cantilever Retaining Wall (CRw) and the Column Cantilever Retaining Wall (CCRw), considering a 35-meter span and heights ranging from 3 to 9 meters. Through a comprehensive evaluation of construction costs, this study concludes that the CCRw configuration offers superior cost-effectiveness compared to the CRw configuration.*
***Keywords:** Cantilever Retaining Wall, Column Cantilever Retaining Wall, IS 456:2000, CRw, CCRw*

I. INTRODUCTION

A retaining wall is an essential construction element that provides support and containment for soil or other substances at different elevations. It has widespread application across the construction industry, serving to prevent erosion, control slopes, and create level surfaces on uneven terrain. Retaining walls are commonly found in residential, commercial, and infrastructure projects.

The primary purpose of a retaining wall is to withstand the lateral pressure exerted by the retained soil or substances. Without a retaining wall, soil naturally tends to move downward due to gravity, leading to slope instability, erosion, and potential damage to nearby structures. By constructing a retaining wall, the soil is effectively confined and prevented from sliding or collapsing.

During the design of a retaining wall, several factors must be considered, including the type of soil being retained, the wall's height and slope, drainage conditions, and anticipated loads and forces acting on the wall. Engineers and architects utilize principles of structural analysis to determine the appropriate dimensions, reinforcement, and construction techniques necessary to ensure the stability and durability of the retaining wall.

A. *Types Of Retaining Walls*

1) Gravity Retaining Wall
2) Semi-gravity Retaining Wall
3) Cantilever Retaining Walls.
4) Counterfort Retaining walls.
5) Buttressed Retaining walls.

II. COLUMN CANTILEVER RETAINING WALL

The Column Cantilever Retaining Wall (CCRw) is a type of retaining wall that incorporates columns at fixed intervals along its length. In comparison to regular Cantilever Retaining Walls (CRw), the moment values in the "X" direction are lower, while the "Y" direction experiences higher moments. In CRw, only the minimum required steel reinforcement is provided based on the wall's cross-sectional area.

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By introducing columns within the stem of the wall, the "Mx" value (moment in the X direction) is increased, while the "My" value (moment in the Y direction) is decreased. This allows for the transfer of certain moments to the columns. Despite the provision of additional columns compared to a conventional cantilever retaining walls, cost savings are achieved by reducing the amount of reinforcement required in the stem.

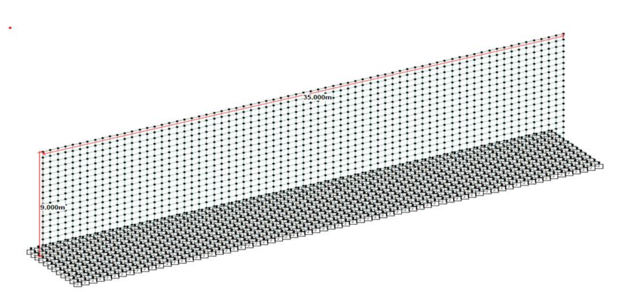	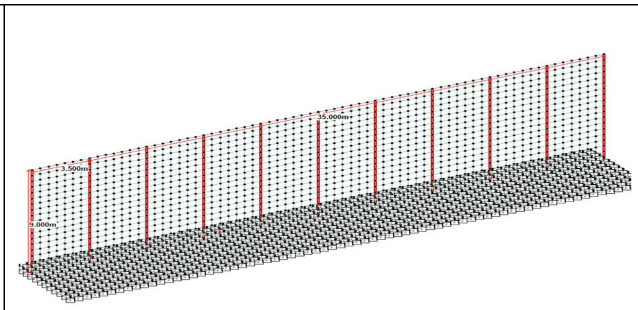
Fig 01-Simple cantilever retaining wall. (CRw)	Fig02- Column cantilever retaining wall. (CCRw)

III. METHODOLOGY

The research methodology employed in this study combines manual calculations, analysis using STAAD Pro software, and the development of Excel design spreadsheets to examine efficient design approaches for retaining walls while adhering to the guidelines outlined in IS 456:2000.

The length of the wall considered in the research is 35 meters. A manual analysis of the Cantilever Retaining Wall (CRw) with a height of 4.5 meters is conducted, considering relevant checks specified in the IS 456:2000 code, such as overturning, stability, tension and shear, and bearing pressure. Excel spreadsheets are prepared to facilitate the design process.

The model analysis includes the following:

1) Cantilever Retaining Wall (CRw) at different heights: 3 meters, 4.5 meters, 6 meters, 7.5 meters, and 9 meters.

2) Column Cantilever Retaining Wall (CCRw) at the same heights as mentioned above.

In the CCRw configuration, columns are introduced at 3.5-meter intervals. Both types of walls are analysed using the designed Excel spreadsheets and STAAD Pro software. The analysis results obtained from STAAD Pro for each height are compared with the analysis results of both types of retaining walls. The output from STAAD Pro is then utilized in the Excel program for design based on the Limit State method. The quantities of concrete and steel are calculated using the designed Excel sheet, and the results are compared.

By employing this methodology, the study aims to gain insights into the design optimization of cantilever retaining walls and the potential benefits of incorporating a column system, while ensuring compliance with relevant standards and codes.

Table 1: Data Assumed for model analysis	
The angle of repose (Φ)	30˚
Density of soil (Y)	18 kN/m^3
Co-efficient of friction between concrete and soil (μ)	0.45
Active Earth Pressure (ka)	1/3
Length of wall	35 m
Concrete Grade	M20
Steel Grade	Fe 415

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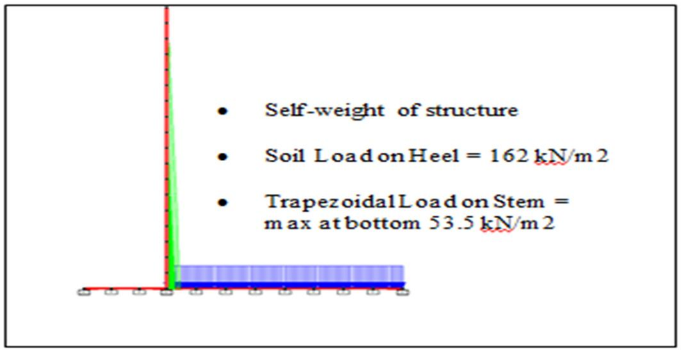

Fig 03 – Loading on retaining wall 9m height.

Table 2- Properties of wall					
L=35m	Stem	Foundation		Column	
Height	Thickness	Width	Thickness	Width	Depth
3.0 m	0.30m	1.80m	0.25m	0.30m	0.450m
4.5 m	0.40m	2.80m	0.30m	0.30m	0.450m
6.0 m	0.45m	3.00m	0.40m	0.30m	0.45m
7.5 m	0.55m	4.50m	0.50m	0.38m	0.60m
9.0 m	0.65m	5.50m	0.75m	0.375m	0.60m

IV. RESULTS AND COMPARISON

Figures 04 and 05 illustrate the moment variation along the Y direction for both the Cantilever Retaining Wall (CRw) and the Column Cantilever Retaining Wall (CCRw) with a height of 9 meters. In the CCRw configuration, columns are positioned at intervals of 3.5 meters along the length.

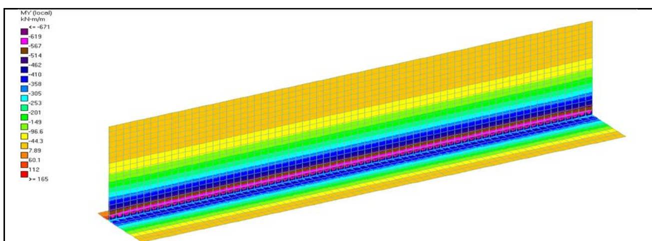

Fig 04- Moment Variation in CRw

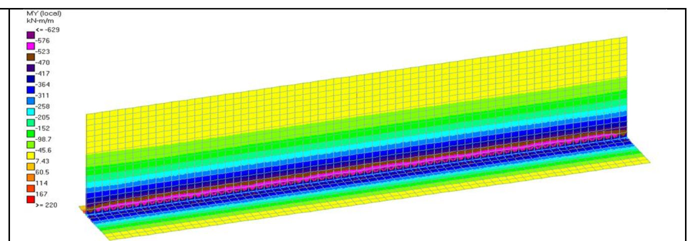

Fig05- Moment Variation in CCRw

Table-03 Max. Stem moment at different heights		
Length= 35	CRw	CCRw
Height	My	My
3.0 m	42 KN-m	39 KN-m
4.5 m	136 KN-m	128 KN-m
6.0 m	324 KN-m	304 KN-m
7.5 m	422 KN-m	396 KN-m
9.0 m	671 KN-m	629 KN-m

Table-04 Comparative Quantities				
Length= 35	CRw		CCRw	
Height	Concrete (m3)	Steel (kg)	Concrete (m3)	Steel (kg)
3.0 m	47.25	2882	48.74 M	2827
4.5 m	92.40	5636	94.63	5488
6.0 m	136.50	8327	139.47	8089
7.5 m	223.13	13611	227.77	13210
9.0 m	349.13	21297	352.84	20465

V. CONCLUSION

Based on the conducted study, the following conclusions have been derived by comparing the manual bending moment results of the retaining wall with and without a column to the results obtained from STAAD Pro:

1) The maximum reduction in the moment along the Y axis is approximately 6-7% when a column is introduced in a traditional cantilever retaining wall.
2) The study reveals that the construction cost can be reduced by 6-7% when a column is utilized instead of a conventional cantilever retaining wall.

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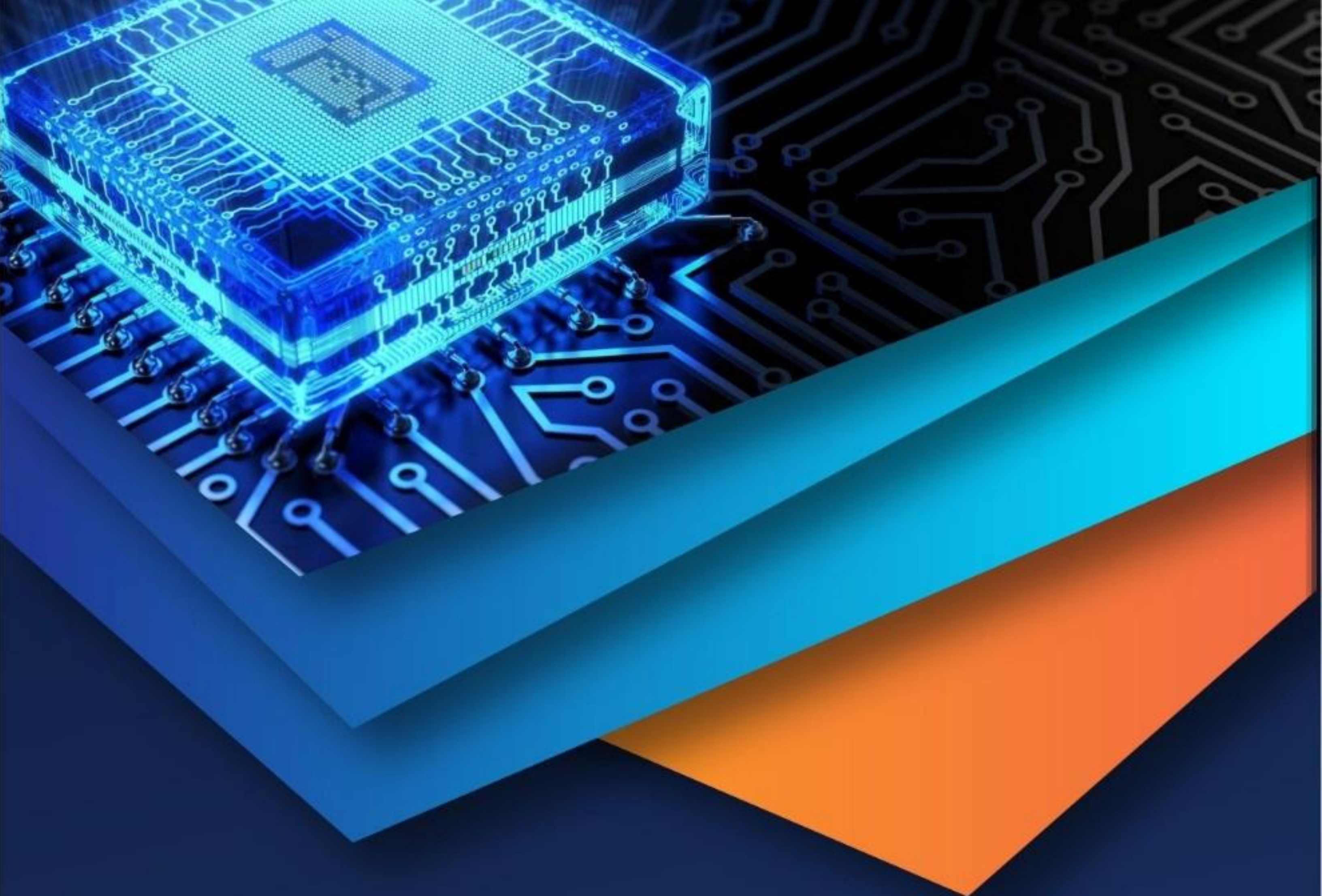

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