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Investigation on Dynamic Behavior of different types of Retaining Walls with Different Heights

Ankit C. Mahure[1], Prof. M. N. Umare[2]
[1]PG Student, [2]Professor, KDK College of Engineering, Nagpur (Maharashtra) India

Abstract: Analyzing the behavior of earth retaining structures under seismic conditions has been very important issue due to their wide applications in several infrastructural applications and other structures. The problem of instability of walls is mainly related to earth pressure distribution on the wall and the response of wall against the earth pressure, especially, under dynamic loading condition.

Soil – wall interaction is an important property which governs the dynamic behavior of the wall. Even after a large number of studies, the dynamic behavior of soil-wall system is still not completely clarifying. The objective of this research is to study the dynamic behavior of cantilever retaining wall along with the earth pressure distribution of soil in seismic conditions. In this paper we want to show design of different types retaining wall such as cantilever retaining wall and L-shape retaining wall with variable height and find out factor of safety against sliding, overturning and Bearing Failure mode.

Keywords: Cantilever Retaining wall, Design ,Dynamic Analysis

I. INTRODUCTION

Analyzing the behavior of earth retaining structures under seismic conditions has been very important issue due to their wide applications in several infrastructural applications and other structures. The major problem of instability of walls is mainly depends on earth pressure distribution on the wall and the response of wall against the earth pressure, especially, under dynamic/seismic loading condition.

Soil – wall interaction is an important property which governs the dynamic behavior of the wall. Even after a large number of studies, the dynamic behavior of soil-wall system is still not completely clarifying. The objective of this research is to study the dynamic behavior of cantilever retaining wall along with the earth pressure distribution of soil in seismic conditions.

Silent features of the dynamic condition on retaining wall, such as:

1) The magnitude of the soil thrust and its point of application;
2) The relative sliding as opposed to rocking of the wall base and the corresponding failure mode such as overturning, sliding, subsidence
3) The importance between soil stiffness, wall dimensions, and excitation characteristics, as affecting the above.

Dynamic earth pressures depend on a large number of parameters such as surcharge angle, backfill density, angle of internal friction of soil, Coefficients of active earth presuure, structural design of wall, ground motion parameters like peak ground acceleration, duration of strong motion and predominant frequency of the earthquake. The predominant frequency of earthquake plays a vital role in behavior of a retaining wall during a dynamic event. Dynamic response of retaining walls to ground motion has been the subject of several studies including both physical modeling and mathematical modeling. The objective of this work is to study the dynamic behavior of a retaining wall along with the earth pressure distribution of soil in dynamic conditions. Among various types of retaining structures, cantilever retaining wall is adopted for the present study.

A. *Cantilever Retaining Wall*

The cantilever wall generally consists of a vertical stem, and a base slab, made up of two distinct regions, viz. a heel slab and a toe slab. All three components behave like one-way cantilever slabs: the „stem" acts as a vertical cantilever above the lateral earth pressure; the „heel slab" and the „toe slab" acts as a horizontal cantilever under the action of the resulting soil pressure. The weight of the earth retained helps in maintaining the stability of the wall.

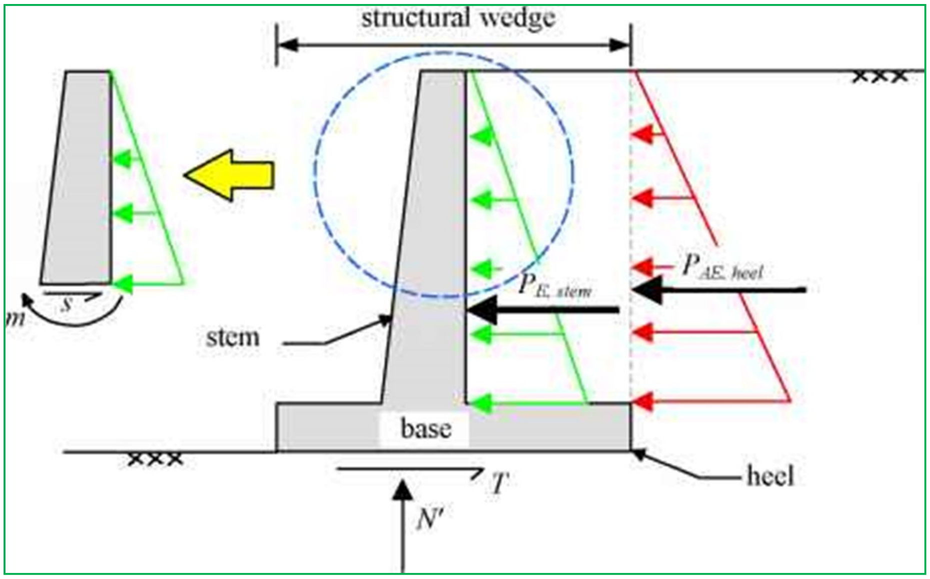

Fig. 1 Cantilever Retaining Wall

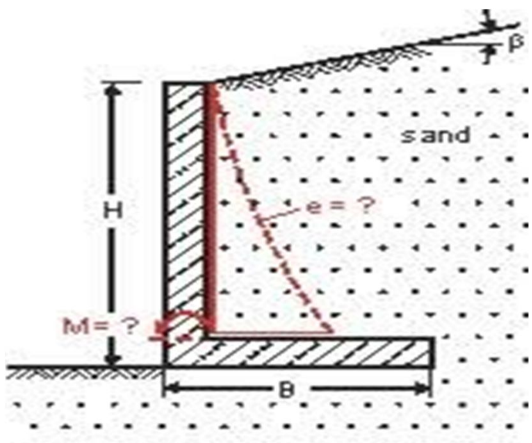

Fig. 2 L- Shaped retaining wall

B. Dynamic Earth Pressure Computation

The methods that are used to compute the dynamic earth pressure on the retaining walls nowadays can be classified into three main groups:

1) Limit state analyses, in which a considerable relative movement occurs between the wall and soil to mobilize the shear strength of the soil
2) Elastic analyses, in which the relative movement in between the soil and wall is limited, therefore the soil behaves within its linear elastic range. The soil can be considered as a linear elastic material.
3) Numerical analyses, in which the soil is modeled with actual non-linear hysteretic behavior.

The most commonly used method to design retaining structures under seismic conditions is force equilibrium based **pseudo-static analysis** (e.g. Mononobe-Okabe 1926, 1929). The limit-state analyses were developed by Mononobe and Okabe (Mononobe and Matuo 1929; Okabe 1924). The Mononobe-Okabe approach has several variants (Kapila 1962, Arango 1969, Seed and Whitman 1970; Richards and Elms 1979; Nadim and Whitman 1983, Richards et al 1999, Choudhury 2002). A wedge of soil bounded by the wall is assumed to move as a rigid block, with prescribe a horizontal and a vertical acceleration. This method was basically developed to calculate the active and passive earth pressure for dry cohesion less materials by Mononobe-Okabe. The use of a graphical construction, such as Coulomb or Mel bye construction procedure, has been described by Kabila (1962). Arango (1969) has developed a simple procedure for obtaining the value of the dynamic lateral earth pressure coefficient for active conditions from standard charts for static lateral earth pressure coefficient for active condition using Coulomb method[1]

II. LITERATURE REVIEW

A. Design of Cantilever Retaining Wall with 4m Height"Tamadher Abood1, HatemE.Younis Eldawi2, Faeza R. Elnaji Abdulrahim3 in present study author want to say Retaining structures hold back soil or other loose material where an abrupt change in ground elevation occurs. The retained material or backfill exerts a push on the structure and thus tends to overturn or slide it, or both. The cantilever is the most common type of retaining wall and is used for walls in the range of 3to 6m in height. This study presents analyses and design of cantilever retaining wall which is made from an internal stem of steel-reinforced, cast-in-place concrete (often in the shape of an inverted T). In this work a detailed analyses and design for this type of walls which include estimation of primary dimensions of the wall, then these dimensions were checked. The factor of safety against sliding, overturning and bearing were calculated. The shear resistance for the base, the tension stresses in the stem and the tension stresses for the base was checked. Calculations of reinforcement for each part of the wall were done. All analysis and design are based on the ACI code.

B. "Design of L-shaped retaining wall A. Rouili World academy of science , engineering and technology International journal of civil science and engineering vol.7 no.12, 2013 in oresent study author want to say that Cantilever L-Shaped walls are known to be relatively economical as retaining solution. The design starts by proportioning the wall of dimensions for which the stability is checked for a ratio between the length of the base and stem, falling between 0.5 to 0.7 ensure in most case the stability requirements , however the displacements pattern of the wall in terms of rotation and translation and the lateral pressure profile do not have the same figure for all walls proportioning as its usually assumed.

C. Design and detailing of retaining wall Dr. IR Erizal, Magr. SIL211 MEKANIKA TANAH, 3(2-3). In present study author want to say that the Retaining wall usually build to hold back soil mass. However, retaining wall can also be constructed for aesthetic landscaping purpose. Earth pressure is the pressure exerted by the retaining materials on the retaining walls, this purpose tends to deflect the wall material.

D. Seismic analysis of L-shaped Quay wall considering soil structure Interaction A. Gharavi and K. bargi 15 WCEE LISBOA 2012 In present study author want to say that the seismic behavior of L-shaped quay walls is conisderd in two condition with or without counterfort. Numerical modeling in finite elements method is used to model the wall and soil behind it. Wall elements consist of concrete and reinforcement which have nonlinear behavior in the seismic analysis. More being more specific in modeling the reinforcement of the concrete are considered in a seismic behavior of the wall.

E. Analysis and Design of stepped cantilever retaining wall Dr. S. S. patil and A. A. R. Bagban International journal of engineering research and technology (IJERT) ISSN: 2278-0181 VOL.4 Issue 02 feb 2017 in present study author want to say that the It is extensively used in variety of situations such as highway engineering, railway engineering, bridge engineering and irrigation engineering. Reinforced concrete retaining wall have a vertical or inclined stem cast with base slab and heel slab. These are considered suitable up to a height of 6m. It resists lateral earth pressure by cantilever action of stem, toe slab and heel slab.

F. Design of rigid L-shaped retaining walls A. Rouili World academy of science, Engineering and technology International journals of civil and environmental engineering Vol 7, No. 12,2013 in present study author want to say that the result of a numerical analysis are presented, different wall geometries were considered. The result show that the proportioning governs the equilibrium between the instantaneous rotation and the translation of the wall-toe, also, the lateral pressure estimation based on the average value between the at rest and the active pressure, recommended by most design standards, is found to be not applicable for all walls.

G. Seismic analysis and design of cantilever retaining wall Shoebmohammadsayeed, sunandanreddy, K. mythili International journal of science engineering and advance technology in present study author want to say that The overall stability of the retaining wall against sliding and overturning must be determined prior to construction giving due regard the site soil condition in particular the bearing capacity of the foundation strata based upon the ability of the ground to withstand the combined actions of vertical, horizontal and rotational loading that the wall transfers to the ground.

III. OBSERVATION, DATA COLLECTION, DESIGN & CALCULATION

1) Calculate earth pressure coefficients based on Rankin's theory and Coulomb's theory.
2) Calculate Lateral earth pressure forces acting on the wall.
3) Analysis of the wall to check various stability conditions and calculate Factor of safety As per IS 456:2000.
4) Calculate horizontal and vertical acceleration coefficients in accordance with Indian standard code IS: 1893 part (3)
5) Calculate seismic earth pressure coefficients in accordance with IRC 6 (2016).

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6) Perform seismic analysis using pseudo-static method of earth pressure analysis.
7) Design of reinforcements for various elements of the wall.

A. RCC Cantilever Retaining Wall

Design cantilever retaining wall to retain on earth embankment with a horizontal top (height) 3.5 meter to 6 meter above ground level. Density of earth, ϒ = 18 Kn/m3. Angle of internal friction φ = 30 and SBC of soil is 200 kN/m2. Take coefficient of friction between soil and concrete = 0.5 Adopt M20 grade concrete and fe-415 steel.

1) Solution

Table no:- 3.1 Given Data

Symbols	Magnitudes	Units
H	3.5 to 6	M
ϒ	18	N/M^3
φ	30	
β	20	
SBC	200	Kn/m^2
μ	0.5	
Fck	415	N/mm^2
Fy	20	N/mm^2
I	90	
θ	10	
δ	90	

Model Name	Height (Meter)	Earth Pressure	Foundation Depth (meter)	Height of Retaining wall (meter)
CRW3	3.0	0.33	1.25	4.25
CRW3.5	3.5	0.33	1.25	4.75
CRW4	4.0	0.33	1.25	5.25
CRW4.5	4.5	0.33	1.30	5.80
CRW5.0	5.0	0.33	1.30	6.30
CRW5.5	5.5	0.33	1.30	6.80
CRW6	6.0	0.33	1.30	7.30

Table no:-3.2 Model Nomenclature

Model Name	Height of Retaining wall (meter)	Width of wall (Meter)	Toe projection (Meter)	Thickness of base slab (meter)	Length of heel (Meter)
CRW3	4.25	2.25	0.675	0.40	1.175
CRW3.5	4.75	2.5	0.75	0.40	1.35
CRW4	5.25	2.75	0.825	0.437	1.525
CRW4.5	5.80	3.1	0.93	0.483	2.17
CRW5.0	6.30	3.3	0.99	0.525	2.31
CRW5.5	6.80	3.5	1.05	0.566	2.45
CRW6	7.30	3.8	1.14	0.608	2.66

Table no:- 3.3 Model Dimensions

Model Name	Total Weight KN	Moment Kn-m	Total pressure	Over turning Moment	Shear Key
CRW3	132.80	190.04	81.93	116.070	Yes
CRW3.5	195.95	289.04	102.343	162.044	Yes
CRW4	234.36	377.35	125.02	218.79	Yes
CRW4.5	291.64	520.28	152.59	295.009	Yes
CRW5.0	348.41	649.41	180.03	378.07	Yes
CRW5.5	394.60	778.13	209.774	475.421	Yes
CRW6	452.68	966.85	241.72	588.194	Yes

Table no:-3.4 Model Stability check

B. RCC L-Shape Retaining Wall

Design L-Shape retaining wall to retain on earth embankment with a horizontal top (height) 3.5 meter to 6 meter above ground level. Density of earth, ϒ = 18 Kn/m3. Angle of internal friction φ = 30 and SBC of soil is 200 kN/m2. Take coefficient of friction between soil and concrete = 0.5 Adopt M20 grade concrete and fe-415 steel.

1) Solution

Table no:- 3.5 Given Data

Symbols	Magnitudes	Units
H	3.5 to 6	M
ϒ	18	N/M^3
φ	30	
β	20	
SBC	200	Kn/m^2
μ	0.5	
Fck	415	N/mm^2
Fy	20	N/mm^2
I	90	
θ	10	
δ	90	

Model Name	Height (Meter)	Earth Pressure	Foundation Depth (meter)	Height of Retaining wall (meter)
CRW3	3.0	0.33	1.25	4.25
CRW3.5	3.5	0.33	1.25	4.75
CRW4	4.0	0.33	1.25	5.25
CRW4.5	4.5	0.33	1.30	5.80
CRW5.0	5.0	0.33	1.30	6.30
CRW5.5	5.5	0.33	1.30	6.80
CRW6	6.0	0.33	1.30	7.30

Table no:- 3.6 Model Nomenclature

Model Name	Height of Retaining wall (meter)	Width of wall (Meter)	Toe projection (Meter)	Thickness of base slab (meter)
CRW3	4.25	2.25	2.1	0.40
CRW3.5	4.75	2.5	2.2	0.40
CRW4	5.25	2.75	2.35	0.437
CRW4.5	5.80	3.1	2.7	0.5
CRW5.0	6.30	3.3	2.8	0.55
CRW5.5	6.80	3.5	3	0.6
CRW6	7.30	3.8	3.2	0.608

Table no:- 5.2.3 Model Dimensions

Model Name	Total Weight KN	Moment Kn-m	Total pressure	Over turning Moment	Shear Key
CRW3	159.40	210.78	81.93	116.070	Yes
CRW3.5	192.54	276.32	102.34	162.044	Yes
CRW4	232.375	391.30	125.02	218.79	Yes
CRW4.5	281.98	589.91	152.59	295.009	Yes
CRW5.0	328.96	750.05	177.18	369.141	Yes
CRW5.5	396.67	1031.82	209.74	475.421	Yes
CRW6	475.42	1224.65	241.72	588.194	Yes

Table no:- 3.7Model Stability check

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IV. RESULT

As per IS 456; 2000 factor of safety calculated and check with design

Model	FOS For Overturning	FOS For Sliding	FOS For subsidence
CRW 3	1.6 > 1.2	1.75 > 1.4	1.43 > 0.75 (B/3)
CRW 3.5	1.60 > 1.2	1.44 > 1.4	1.47 > 0.83 (B/3)
CRW 4	1.55 > 1.2	1.41 > 1.4	1.61 > 0.91 (B/3)
CRW 4.5	1.5 > 1.2	1.44 > 1.4	1.78 > 1.0 (B/3)
CRW 5	1.54 > 1.2	1.46 > 1.4	1.81 > 1.1 (B/3)
CRW 5.5	1.47 > 1.2	1.42 > 1.4	1.97 > 1.16 (B/3)
CRW 6	1.48 > 1.2	1.41 > 1.4	2.1 > 1.26 (B/3)

Table No:- 4.1 Cantilever Retaining Wall

Model	FOS For Overturning	FOS For Sliding	FOS For subsidence
L Shape 3	1.94 > 1.2	1.74 > 1.4	1.05 > 0.75 (B/3)
L Shape3.5	2.1 > 1.2	1.41 > 1.4	1.34 > 0.83 (B/3)
L Shape 4	2.4 > 1.2	1.40 > 1.4	1.68 > 0.91 (B/3)
L Shape4.5	2.72 > 1.2	1.4 > 1.4	2.09 > 1.0 (B/3)
L Shape 5	2.76 > 1.2	1.40 > 1.4	2.28 > 1.1 (B/3)
L Shape5.5	2.95 > 1.2	1.43 > 1.4	2.6 > 1.16 (B/3)
L Shape 6	2.8 > 1.2	1.43 > 1.4	2.67 > 1.26 (B/3)

Table No:-4.2 L shape retaining wall

A. Steel Quantity

Sr. no	Height m	Cantilever retaining wall Ast in Kg/m^3	L shape retaining wall Ast in Kg/m^3	Difference in Ast in Kg/m^3
1	3	32.39	33.26	0.87
2	3.5	34.63	36.44	1.81
3	4	38.52	40.53	2.01
4	4.5	40.9	42.98	2.08
5	5	58.81	60.11	3.53
6	5.5	64.13	68.29	4.16
7	6	68.78	75.11	6.33

Table no4.3 Comparison in steel between cantilever and L shape retaining wall

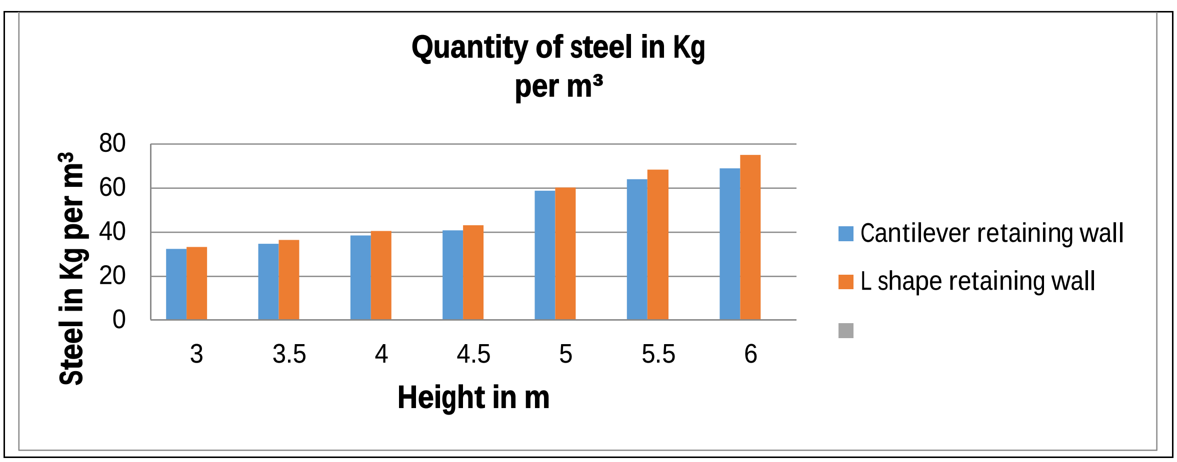

Fig. 4.1 Shows comparison of quantity of steel between Cantilever Retaining wall and L shape Retaining wall

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1) *Discussion:* From above graph its show that the height of retaining wall in X-axis and steel in kg/m^3 in Y- axis. From above graph it conclude that the increase in steel with increase in height. And graph show that the L shape retaining wall consume more steel than the cantilever retaining wall.

B. Quantity Of Concrete

Sr. no	Height	Cantilever retaining wall concrete in cum	L shape retaining wall concrete in cum	Difference in concrete in cum
1	3 m	4.623	4.79	0.167
2	3.5 m	5.76	5.96	0.2
3	4 m	7.27	7.74	0.47
4	4.5 m	9.95	10.58	0.63
5	5 m	11.91	12.68	0.77
6	5.5 m	16.35	17.58	1.23
7	6 m	18.21	19.76	1.55

Table no. 4.4 comparison in concrete between cantilever and L shape retaining wall

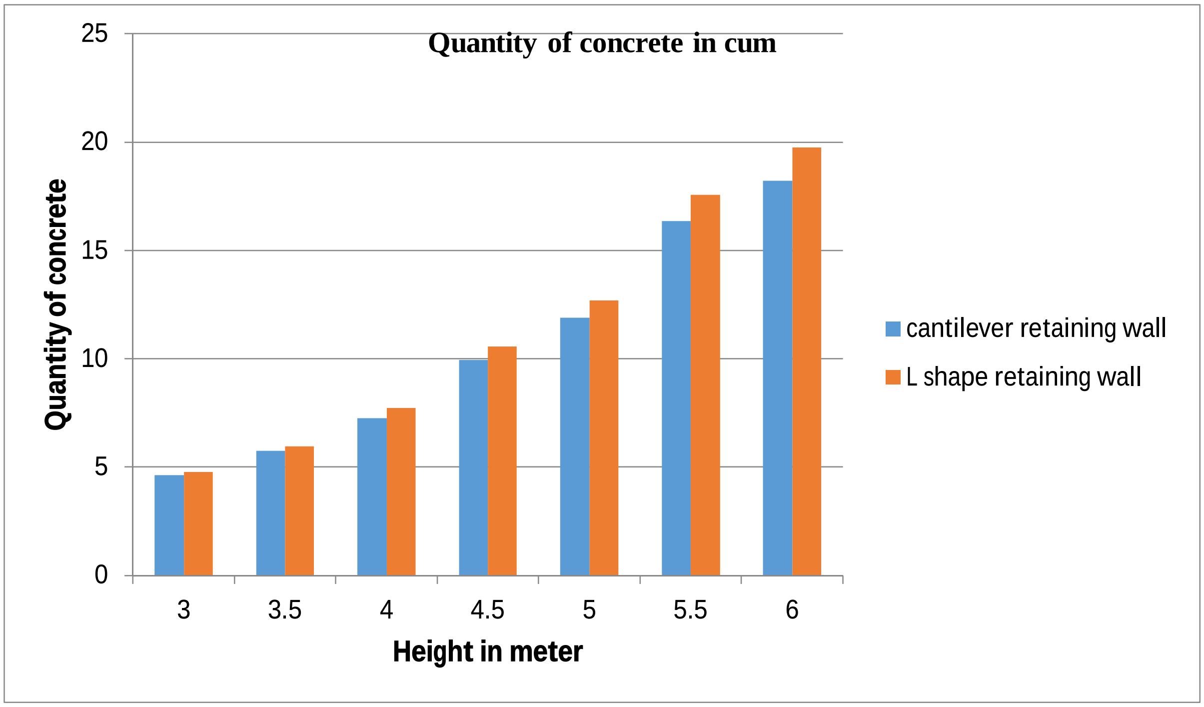

Fig.4.2 shows comparison of quantity of concrete between cantilever retaining wall and L shape retaining wall

1) *Discussions:* From above graph its show that the height of retaining wall in X-axis and quantity of concrete in Y- axis. From above graph it conclude that the increase in quantity of concrete with increase in height. And graph show that L shape retaining wall consume more concrete than the cantilever retaining wall

V. CONCLUSIONS

A. Difference in steel increases with increase in heights, The reason behind that the required Ast will increases with increase in height.

B. Maximum steel required for L shape retaining wall than the cantilever retaining wall. Due to The thickness of steam in L shape retaining wall is more than the cantilever retaining wall.

C. Difference in concrete increases with increase in height, The reason behind that the L shape retaining wall having greater wall thickness than the cantilever retaining wall.

D. L Shape retaining wall consume more concrete than the cantilever retaining wall.

REFERENCES

[1] Ankit C. Mahure, Mr. M. N. Umare A review on dynamic behavior of different types of retaining wall with different heights, International journal for research in applied science & Engineering Technology (IJRASET) ISSN :2321-9653 VOLUME 7, Issue 4, April 2019.

[2] Design of Cantilever Retaining Wall with 4m Height Tamadher Abood1, HatemE.Younis Eldawi2, Faeza R. Elnaji Abdulrahim3 1, 2,3 Omar Al-Mukhtar University, Civil Engineering Department –AL- Quba- Libya International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online) Vol. 3, Issue 1, pp: (318-326), Month: April 2015 - September 2015, Available at: www.researchpublish.com

[3] Behavior of cantilever retaining walls under seismic conditions Anurag UPADHYAY[1], A.MURALI KRISHNA[2] and K.D.SINGH 5th International conference on earthquake geotechnical engineering january 2011, 10-13 santiago,Chile.

[4] Seismic design of earth retaining structures by Atop Lego, M.tech (struct.) SSW (E/Z) AP PWD; Itanagar.

[5] Analysis and design of cantilever retaining wall by dr. S. S PatilandA. R. Bagban International journal of engineering research and technology (IJERT)ISSN: 2278-0181 Vol. Issue 02, february-2015.

[6] Experimental Investigation of dynamic behaviour of cantilever retaining walls by A. scotto di santolo, A. penna and Evangelista p. kloukinas and G.E. Mylonakis A.I. Simonelli s. Bhattacharya, M. Dietz, L. Dihoru and C.A taylor 15 WCEE LISBOA 2012.

[7] Design of L-shaped retainingwall A. Rouili World academy of science , engineering and technology International journal of civil science and engineering vol.7 no.12, 2013.

[8] Design and detailing of retaining wall Dr. IR Erizal, Magr. SIL211 MEKANIKA TANAH, 3(2-3).

[9] Seismic analysis of L-shaped Quay wall considering soil structure Interaction A. Gharavi and K. bargi 15 WCEE LISBOA 2012.