# Non Linear Analysis of Earth-Retaining Walls Using Ansys Workbench

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***Abstract***- *This review study contemplates the relevant theories to understand response of retaining wall in static and seismic condition. The heavy soil mass is supported by retaining walls in various fields of civil engineering such as hydraulics, irrigation structures, highways, railways, tunnels, mining etc. Evaluation of lateral earth pressure is key factor to design retaining wall. In the static condition, the lateral earth pressure exerted by retained soil mass only. In some cases, the deformation in retaining wall due static loading may be negligibly small; in others it cause significant damage. In earthquake prone area, earthquake can induce large destabilizing force in retaining wall and backfill soil, seismically induced force has greater influence on lateral earth pressure. Earthquakes have caused permanent deformations in retaining wall in many historical earthquakes. In some cases, retaining walls have collapsed during earthquake with disastrous physical and economic consequences. Meanwhile, it is very much important to evaluate dynamic earth pressure accurately. This review shows the development of concept to evaluate dynamic lateral earth pressure based on analytical, experimental and numerical method for computation of dynamic lateral earth pressure. The current research brings a comprehensive and categorized review of response of retaining wall system in static condition and dynamic condition.*

***Keywords***- seismic behavior, damping systems, Retaining wall , lateral earth pressure, Ansys workbench.

## I. INTRODUCTION

Retaining wall systems, consisting mainly of a retaining wall and backfill soil, is a prevalent structure used in our built environment including basement wall, bridge abutments, residential elevations, highway walls and so on. The engineering essence of retaining wall is to keep the retained soil in certain shape and prevent it from falling (stability), or to restrain the deformation of the wall and the backfill to maintain its service function (serviceability). Lateral earth pressure generated by retained backfill on the wall and relevant soil / wall deformations are two main facets of engineering design and analysis of retaining walls. Dynamic/seismic response of such system is one of the major areas due to the influence of dynamic force on the lateral pressure, soil / wall deformation. There are quite a number of analytical solutions, experimental investigations and numerical studies that have been conducted in this area due to different soils, wall structures, dynamic and structural conditions etc. In the meanwhile, it is widely accepted that traditional methods have insufficiencies especially under certain circumstances. As a result, there is a diversity of research to address this issue and try to accurately capture the dynamic response of various retaining systems. However, there is currently no comprehensive and categorized review of current research for dynamic retaining walls. As a result, it is valuable to produce a review of current theoretical solutions and their features; also, significant experimental findings and numerical studies are listed and evaluated. The purpose is to provide peer researchers an overview of the types of research in this area and provides introductive descriptions and critical comments for past studies.

In this study non linear analysis of retaining wall is studied including soil structure interaction for various types of walls for silty soil, clay soil and sandy soil.

**The scope of this review:**

1. Studies that proposed fundamental theories or their significant improvements for retaining walls' non linear analysis
2. Analytical, experimental or numerical findings that expose new aspects of wall behavior with a significant physical or mechanism basis.

### 1.1 OBJECTIVES

1. To Study Finite Element Modeling Of Retaining Wall Using ANSYS
2. To Study Effect Height Of Retaining Wall More Than 10 m.
3. To Validate Fem Model With Approximate Method For Checking Accuracy

4. To Compare Various Design Parameter For Retaining Wall In Accordance With IS 456-2000

## II. SCOPE OF DEVELOPMENT

Every theory is extract of experimental study and it is generalization of natural phenomena exist in physical world. The experimental study includes a controlled environment, which stimulates same effects as retaining wall behaves in site condition. According to Veletsos and Younan (1994)[13], the amplification of dynamic earth pressure at resonance is less than the amplification of peak acceleration in dynamic condition. This was very apparent in centrifuged model test by Steedman (1984) and Andersen et al (1991). Anissa Maria hidayati, Sri Prabandi Yani, Wayan Redana, 2015 [21] found the increase in frequency of vibration and density of backfill soil on particular amplitude cause increment in dynamic pressure. Agatino Simoni Lo Grasso, Michel Maugeri, and Ernesto Motta (2005) [22] experimentally found the dynamic pressure distribution is strongly influenced by wall movement; an elastic displacement is exerted by wall during initial stage of motion and permanent wall displacement found at large acceleration level. A reduction of soil wall friction observed at large increment of acceleration. A. Bhattacharjee and A. Murali Krishna (2009) [23] found that the displacement of gravity retaining wall can be determined with considerable accuracy by using compute program FLAC 3D. The acceleration increased with the height of backfill. The accelerations are decreased with increase in damping of backfill. Siavash Kouravand Bardpareh, Ashkan G. Holipoor Noroozi and Alborz Hajiannia (2016) [25] found that the movement of retaining wall during excavation been increases. The influence of compaction behind the retaining walls were carried out with computer program (FEM) explored the effect of construction sequences on the behaviour of a backfilled retaining wall. The construction sequence is a critical factor to be considered in the design stage of gravity type walls.

## III. METHODOLOGY

A major challenge to performance-based design is to develop an efficient and effective general methodology for the design of structures at multiple performance and hazard levels. Improved procedures are needed for the assessment of strength and deformation capacities of retaining wall , components and systems at all performance levels. Addressing multiple performance objectives will require more complex and time consuming analytical techniques to evaluate the non linear analysis of retaining wall. This is expected to increase building development and design cost. These nonlinear analysis procedures need to be calibrated and their adequacy verified [15]. Eventually, consideration needs to be given to the complete soil structure system, all nonstructural systems and components and the retaining wall contents. Appropriate acceptance criteria for site performance in terms of permissible foundation settlements, lateral spreading, liquefaction and faulting will need to be established for each performance objective

### 3.1 PROBLEM STATEMENT

A R.C.C. retaining wall with counter forts is required to support earth to a height of 9 m above the ground level. The top surface of the backfill is horizontal. The trial pit taken at the site indicates that soil of bearing capacity 220 kN/m2 is available at a depth of 1.25 m below the ground level. The weight of earth is 18 kN/m3 and angle of repose is 30°. The coefficient of friction between concrete and soil is 0.58.Use concrete M20 and steel grade Fe 415. Design the retaining wall.

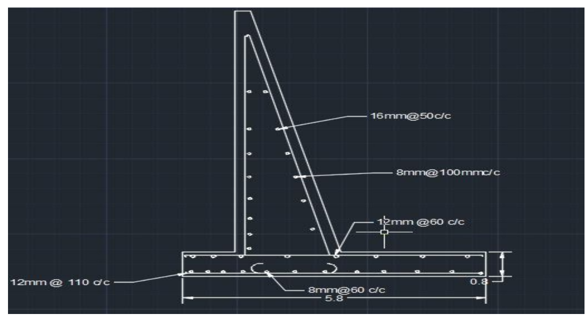



Fig 1. Reinforcement Detail in Retaining Wall

## IV. RESULT AND DISCUSSION

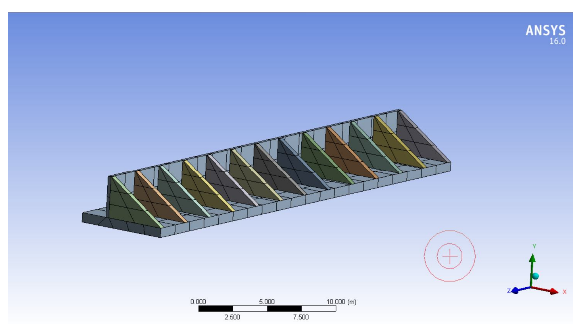



Fig 2. Modeling of Retaining wall in ANSYS

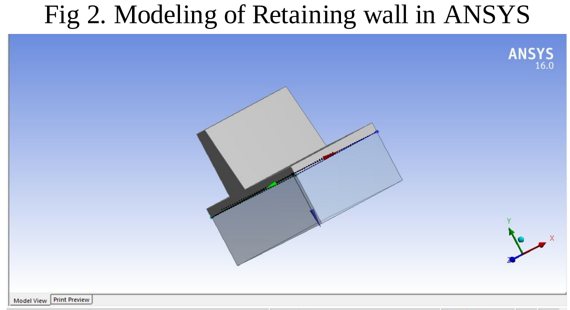
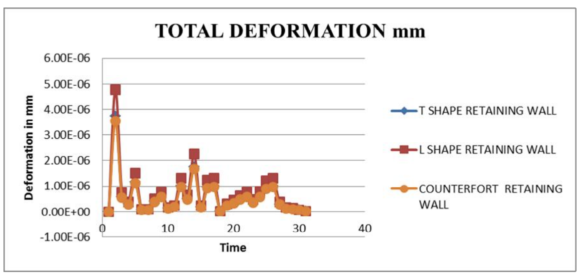



Fig 3. Modeling of Retaining wall in ANSYS

### 4.1 Total Deformation mm

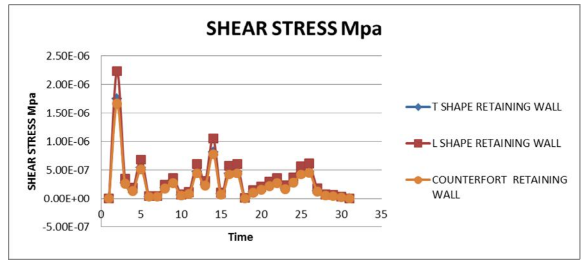
| | TOTAL DEFORMATION mm | | |
|---|---|---|---|
| TIME | T SHAPE RETAINING WALL | L SHAPE RETAINING WALL | COUNTERFORT RETAINING WALL |
| 1 | 5.19E-13 | 6.65795E-13 | 4.94353E-13 |
| 2 | 3.73E-06 | 4.77642E-06 | 3.54649E-06 |
| 3 | 5.79E-07 | 7.42896E-07 | 5.516E-07 |
| 4 | 3.06E-07 | 3.92132E-07 | 2.91158E-07 |
| 5 | 1.16E-06 | 1.49107E-06 | 1.10712E-06 |
| 6 | 6.83E-08 | 8.75345E-08 | 6.49944E-08 |
| 7 | 7.30E-08 | 9.35946E-08 | 6.9494E-08 |
| 8 | 3.97E-07 | 5.08913E-07 | 3.77868E-07 |
| 9 | 6.10E-07 | 7.82377E-07 | 5.80915E-07 |
| 10 | 1.31E-07 | 1.68168E-07 | 1.24865E-07 |
| 11 | 1.88E-07 | 2.40874E-07 | 1.78849E-07 |
| 12 | 1.01E-06 | 1.29693E-06 | 9.62968E-07 |
| 13 | 5.18E-07 | 6.63498E-07 | 4.92647E-07 |
| 14 | 1.75E-06 | 2.24519E-06 | 1.66705E-06 |
| 15 | 1.79E-07 | 2.3001E-07 | 1.70782E-07 |




Graph 1 Total Deformation mm

### 4.2 Shear Stress Mpa

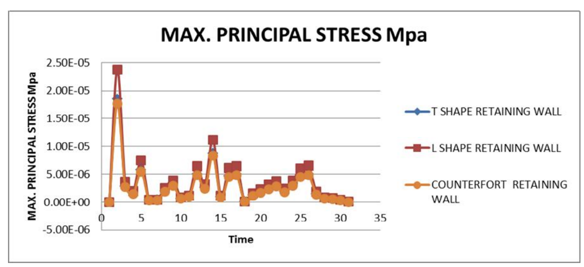
| SHEAR STRESS Mpa | | | |
|---|---|---|---|
| TIME | T SHAPE RETAINING WALL | L SHAPE RETAINING WALL | COUNTERFORT RETAINING WALL |
| 1 | 0.00E+00 | 0 | 0 |
| 2 | 1.75E-06 | 2.23753E-06 | 1.66137E-06 |
| 3 | 2.71E-07 | 3.48018E-07 | 2.58403E-07 |
| 4 | 1.43E-07 | 1.83704E-07 | 1.36401E-07 |
| 5 | 5.40E-07 | 6.92155E-07 | 5.13925E-07 |
| 6 | 3.17E-08 | 4.06349E-08 | 3.01714E-08 |
| 7 | 3.39E-08 | 4.34465E-08 | 3.2259E-08 |
| 8 | 1.84E-07 | 2.3624E-07 | 1.75408E-07 |
| 9 | 2.83E-07 | 3.63198E-07 | 2.69675E-07 |
| 10 | 6.09E-08 | 7.80688E-08 | 5.79661E-08 |
| 11 | 8.80E-08 | 1.12842E-07 | 8.37848E-08 |
| 12 | 4.70E-07 | 6.02065E-07 | 4.47033E-07 |
| 13 | 2.40E-07 | 3.08009E-07 | 2.28697E-07 |
| 14 | 8.20E-07 | 1.05179E-06 | 7.80953E-07 |
| 15 | 8.33E-08 | 1.06776E-07 | 7.92813E-08 |




Graph 2 Shear Stress Mpa

### 4.3 Max. Principal Stress Mpa

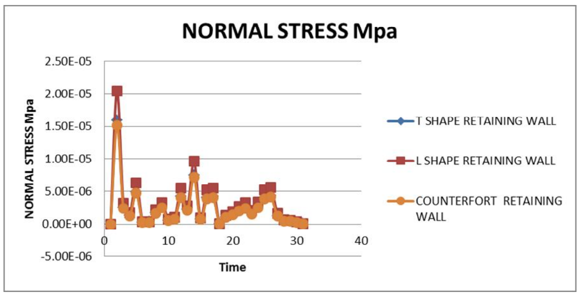
| MAX. PRINCIPAL STRESS Mpa | | | |
|---|---|---|---|
| TIME | T SHAPE RETAINING WALL | L SHAPE RETAINING WALL | COUNTERFORT RETAINING WALL |
| 1 | 2.74E-12 | 3.50975E-12 | 2.60599E-12 |
| 2 | 1.85E-05 | 2.37692E-05 | 1.76487E-05 |
| 3 | 2.88E-06 | 3.69706E-06 | 2.74506E-06 |
| 4 | 1.52E-06 | 1.95136E-06 | 1.44888E-06 |
| 5 | 5.79E-06 | 7.42012E-06 | 5.50944E-06 |
| 6 | 3.40E-07 | 4.35626E-07 | 3.23453E-07 |
| 7 | 3.63E-07 | 4.65841E-07 | 3.45887E-07 |
| 8 | 1.98E-06 | 2.53268E-06 | 1.88052E-06 |
| 9 | 3.04E-06 | 3.8936E-06 | 2.891E-06 |
| 10 | 6.53E-07 | 8.36959E-07 | 6.21442E-07 |
| 11 | 9.35E-07 | 1.19865E-06 | 8.89999E-07 |
| 12 | 5.03E-06 | 6.45427E-06 | 4.7923E-06 |
| 13 | 2.58E-06 | 3.30198E-06 | 2.45172E-06 |
| 14 | 8.72E-06 | 1.11733E-05 | 8.29615E-06 |
| 15 | 8.93E-07 | 1.14474E-06 | 8.49972E-07 |




Graph 3 Max. Principal Stress Mpa

### 4.4 Normal Stress Mpa

| NORMAL STRESS Mpa | | | |
|---|---|---|---|
| TIME | T SHAPE RETAINING WALL | L SHAPE RETAINING WALL | COUNTERFORT RETAINING WALL |
| 1 | 5.87E-13 | 7.5306E-13 | 5.59147E-13 |
| 2 | 1.60E-05 | 2.04587E-05 | 1.51906E-05 |
| 3 | 2.48E-06 | 3.18199E-06 | 2.36263E-06 |
| 4 | 1.31E-06 | 1.67957E-06 | 1.24708E-06 |
| 5 | 4.94E-06 | 6.33745E-06 | 4.70556E-06 |
| 6 | 2.90E-07 | 3.72068E-07 | 2.76261E-07 |
| 7 | 3.10E-07 | 3.97822E-07 | 2.95383E-07 |
| 8 | 1.69E-06 | 2.16308E-06 | 1.60609E-06 |
| 9 | 2.59E-06 | 3.32548E-06 | 2.46917E-06 |
| 10 | 5.58E-07 | 7.1482E-07 | 5.30754E-07 |
| 11 | 8.05E-07 | 1.03171E-06 | 7.66046E-07 |
| 12 | 4.30E-06 | 5.51258E-06 | 4.09309E-06 |
| 13 | 2.20E-06 | 2.82018E-06 | 2.09398E-06 |
| 14 | 7.50E-06 | 9.61646E-06 | 7.14022E-06 |
| 15 | 7.63E-07 | 9.77671E-07 | 7.25921E-07 |




Graph 4 Normal Stress Mpa

## V. CONCLUSION

- It has been observed by parametric study that active earth pressure coefficient are almost identical by different methods, it can be noted from the graphical representations of the results obtained from the application of the different theories.
- Height of Retaining wall more than 10 m will give sufficient result for the deformation, shear stress, normal stress, strain energy etc value give satisfactory result.
- It is observed that counter fort retaining wall has more capacity than T-shaped and L-shape retaining walls.

## REFERENCES

[1] Syed Mohd. Ahmad "Stability Of Waterfront Retaining Wall Subjected To Pseudo-Dynamic Earthquake Forces And Tsunami"Journal of Earthquake and Tsunami, Vol. 2, No. 2 (2008).

[2] Siddharth Mehta and Siddharth Shah "Seismic Analysis Of Reinforced Earth Wall: A Review" IJSCER Vol. 4, No. 1, February 2011.

[3] T. Manda, R. Jadhav "Behaviour Of Retaining Wall Under Static And Dynamic Passive Earth Pressure" Datta Meghe College of Engineering, Mumbai, Proceedings of Indian Geotechnical Conference December 15-17, 2011, Kochi.

[4] Mahmoud Yazdani, Ali Azad "Extended ''Mononobe-Okabe'', Method for Seismic Design of Retaining Walls" Journal of Applied Mathematics Volume 2013, Article ID 136132, Vol.3, 2012.

[5] Su Yang, Amin Chegnizadeh "Review of Studies on Retaining Wall's Behavior on Dynamic / Seismic Condition"IJERA, Vol. 3, Issue 6, Nov 2013

[6] S.A.Ingale , S.Y.Kale "Comparison Study of Static and Dynamic Earth Pressure behind the Retaining Wall",(IOSRJMCE,Volume 12, Issue 3 Ver. I 2015

[7] B. Mendez1 , D. Rivera "Dynamic Soil Pressures on Embedded Retaining Walls: Predictive Capacity Under Varying Loading Frequencies"6th International Conference on Earthquake Geotechnical Engineering 1-4 November 2015.

[8] A. Scotto di Santolo1 , A. Penna2 & A. Evangelista "Experimental Investigation of Dynamic Behaviour of Cantilever Retaining Walls"University of Naples Federico II, 2 CIMA-AMRA

[9] Leuzzi Francesco "Dynamic Response of Cantilever Retaining Walls Considering Soil Non-Linearity"University of Patras, 26500 Rion

[10] Hoe I. Ling, M.ASCE "Parametric Studies on the Behavior of Reinforced Soil Retaining Walls under Earthquake Loading" 2017