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Comparison Study of Static and Dynamic Earth Pressure behind the Retaining Wall

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Abstract: *As the retaining walls are very important structures in civil engineering so proper design is required in seismic condition. To examine the seismic active pressure on retaining walls, the pseudo-dynamic method is adopted in deducing the formulas of seismic active earth pressure. The critical rupture angle is analytically evaluated on the basis of conventional sliding wedge limit equilibrium theory. In the present work, the earth pressure is evaluated by all statics methods viz. Rankine's method, Coulombs method (analytical) and Poncelet's, Culmann's (graphical method). Also, Seismic earth pressure is evaluated by IS code method and Mononobe Okabe method and finally comparisons of them. The earth pressure is calculated for three types of backfills viz. Soft murrum, Hard murrum, and Black cotton soil. Finally, the percentage difference between static and dynamic Earth pressure is ranging between 9.35-10.66%*
Keywords: *Static earth pressure, Seismic earth pressure, Retaining wall, M-O Method*

I. Introduction

The determination of seismic earth pressure acting on a retaining wall is a particularly important problem in the design of many geotechnical engineering structures in the seismic zone. For many decades, a number of investigators have developed several methods to estimate the seismic earth pressure on a rigid retaining wall due to earthquake loading. Okabe, Mononobe and Matsuo provided a solution to determine the earth pressure on the basis of limit-equilibrium approach, which is an extension of the Coulomb sliding wedge theory. This pseudo-static method is widely known as the Mononobe-Okabe method. Later, this approach, modified by Saran and Gupta, is applicable to cohesive soil backfill. They presented an expression of the total seismic active earth pressure by adding the separately calculated maximum pressure contributions caused by the weight of soil wedge, cohesion of the soil backfill, resulting in different failure planes, which is not compatible with practical situations. Rao and Choudhary the pseudo-static method assumes that the magnitude and phase of acceleration are uniform throughout the backfill, which could not consider the real dynamic nature of earthquake acceleration. In order to remove this deficiency, Steedman analyzed the seismic earth pressure in soil considering composite failure surface following the same approach. All of the mentioned studies applied the pseudo-static method to estimate seismic active force, which considered the seismic loading induced by earthquake to be time-independent.

II. Experimental Investigations

In this work, different soil samples from the following sites have taken:

- Tilekar Nagar (Kondhwa Bk.) Pune

1. Soft Murrum
2. Hard Murrum
3. Black Cotton Soil

2.1 Laboratory Analysis

2.1.1 Specific Gravity (IS 2720-IV)

The specific gravity measured by pycnometer for each soil sample as per IS.2720 Part III.
The average specific gravity is tabulated as shown below.

Table 1: Specific gravity for various soil samples

Sr. No.	Types of soil	Specific Gravity (G)
1	Soft Murrum	2.308
2	Hard Murrum	2.440
3	Black Cotton Soil	2.040

2.1.2 Grain Size Distribution (IS 2720: PART IV)

The grain size distribution curves for various soil sample are as shown below Dry sieve analysis is performed. (IS 2720: Part IV)

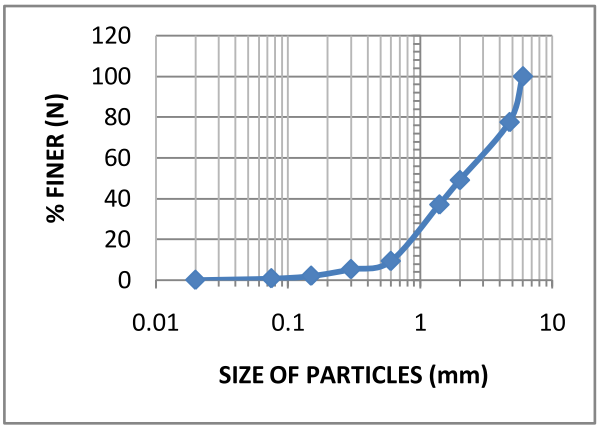

Fig.1: Gradation curve for SOFT MURRUM

The above gradation curve shows that the relation between size of particle and % finer of hard murrum soil sample and the values of D_{10}=0.5, D_{30}=1.01, & D_{60}=3, are calculated as Cu=6 & Cc=0.68. Hence, the soil is well graded Soil (WG).

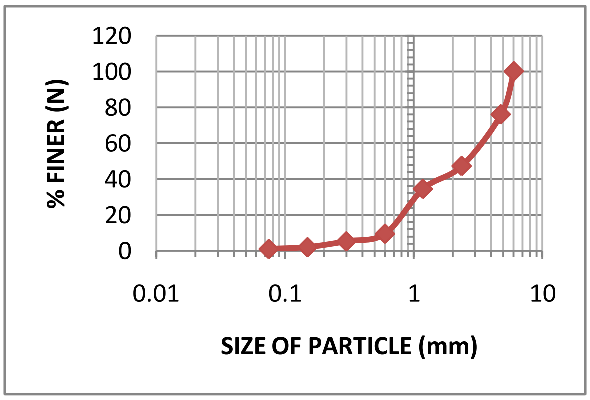

Fig.2: Gradation curve for HARD MURRUM

The above gradation curve shows that the relation between size of particle and % finer of Soft murrum soil sample and the values of D_{10}= 0.6, D_{30}=1.01, & D_{60}=4, are calculated as Cu=6.67 & Cc=0.42. Hence, the soil is well graded Soil (WG).

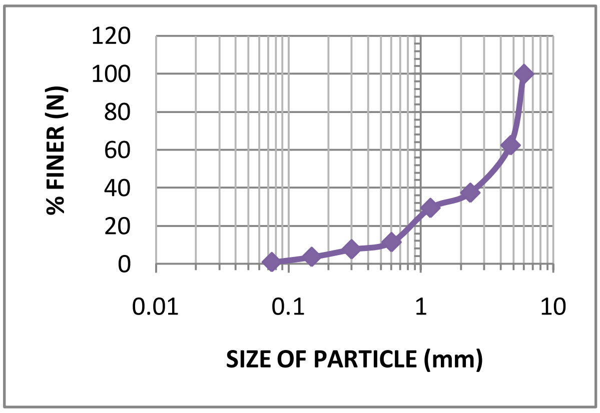

Fig.3: Gradation curve for BLACK COTTON SOIL

The above gradation curve shows that the relation between size of particle and % finer of Black cotton soil sample and the values of D10= 0.30, D30=1.01, & D60=5, are calculated as Cu=16.67 & Cc=0.68. Hence, the soil is well graded Soil (WG).

2.2 Standard Proctor Test (IS.2720-VIII)

The standard Proctor tests are performed for different soil sample by using Standard proctor test apparatus as per IS.2720 Part VIII as shown below:

2.2.1: Soft Murrum:-

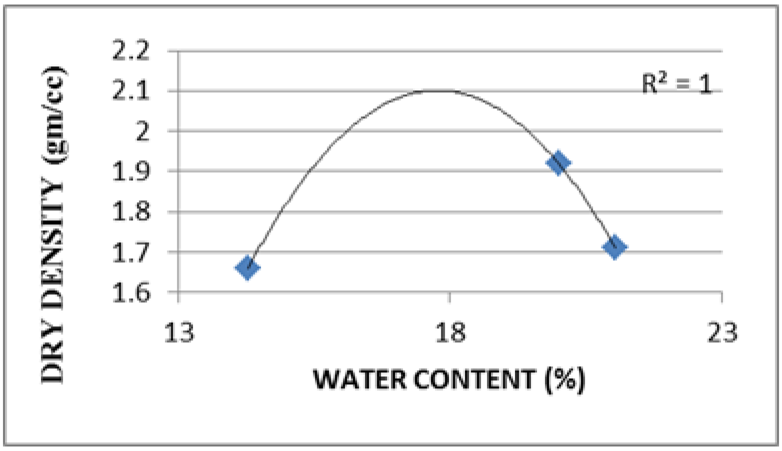

Fig.4: Standard proctor test for SOFT MURRUM

Standard proctor test is performed on Soft murrum. The above curve shows that the relation between water content and dry density of soft murrum.

OMC = 18%

MDD = 2.1

2.2.2: Hard Murrum:-

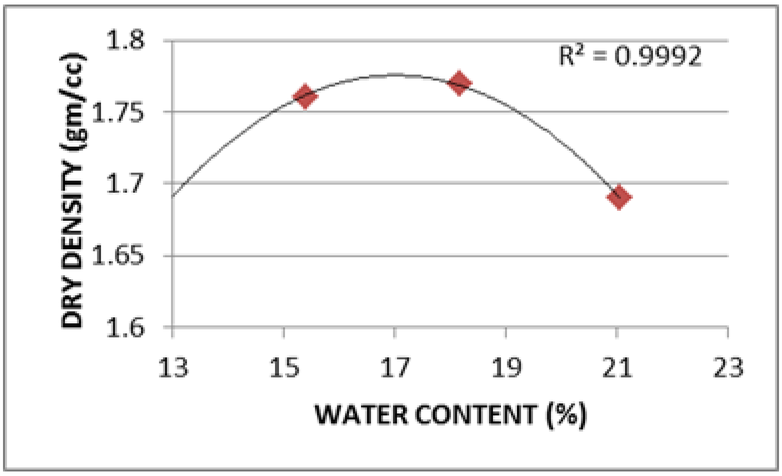

Fig.5: Standard proctor test for HARD MURRUM

Standard proctor test is performed on Hard murrum. The above curve shows that the relation between water content and dry density of hard murrum.

OMC = 17%

MDD = 1.77

2.2.3: Black Cotton Soil:-

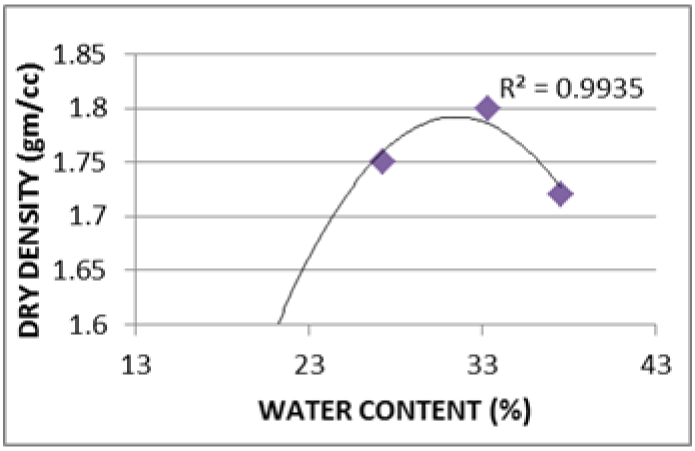

Fig.6: Standard proctor test for BLACK COTTON SOIL

Standard proctor test is performed on Black cotton soil. The above curve shows that the relation between water content and dry density of Black cotton soil.
OMC = 31
MDD = 1.79

2.3 Direct Shear Test (IS.2720-XIII)

The Direct shear test is performed for different soil sample by using direct shear test apparatus as per IS.2720 Part XIII as shown below:

2.3.1 Soft Murrum: Without Geomembrane

Table .2: Direct shear test for soft murrum.

Normal Stress (kg/cm^2)	**Shear Stress (kg/cm^2)**
0.5	0.5
1.0	0.8
2.0	1.2

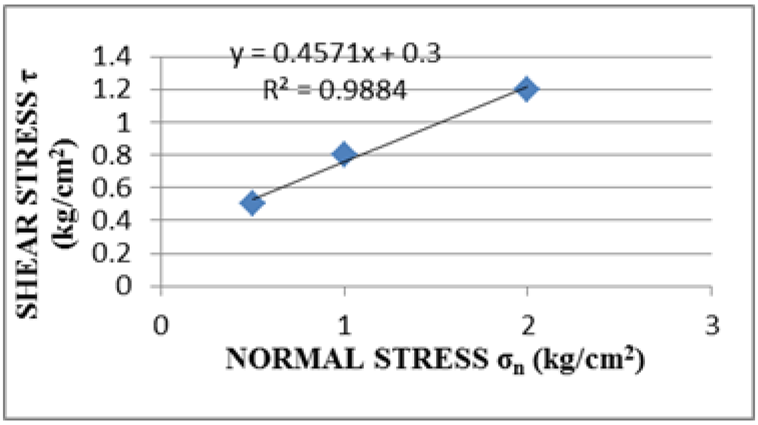

Fig.7: Direct shear test for SOFT MURRUM

C = 0.3

$\Phi = 24.57^o$

2.3.2 Hard Murrum: Without Geomembrane

Table .3: Direct shear test for Hard Murrum

Normal Stress (kg/cm^2)	**Shear Stress (kg/cm^2)**
0.5	0.5
1.0	0.9
2.0	1.4

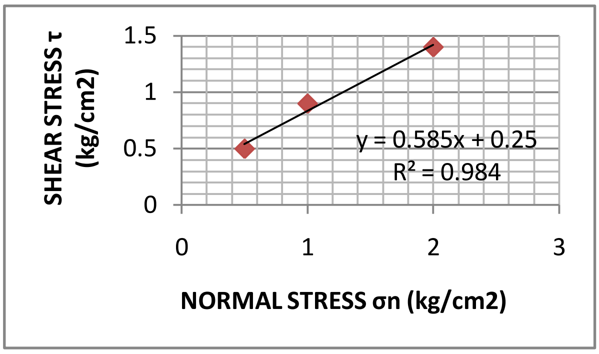

Fig.8: Direct shear test for HARD MURRUM

C = 0.25
$\Phi = 30.31^o$

2.3.3 Black Cotton Soil: Without Geomembrane

Table .4: Direct shear test for Black cotton soil

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)
0.5	0.5
1.0	0.8
2.0	1.2

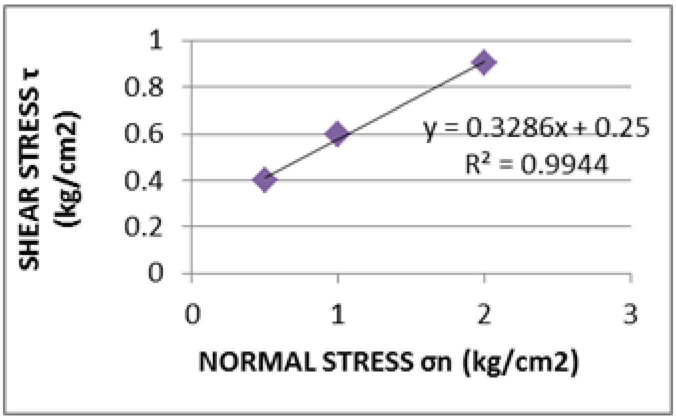

Fig.9: Direct shear test for BLACK COTTON SOIL

C = 0.25
$\Phi = 18.19^o$

2.3.4 Soft Murrum: With Geomembrane

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)
0.5	0.35
1.0	0.65
2.0	0.95

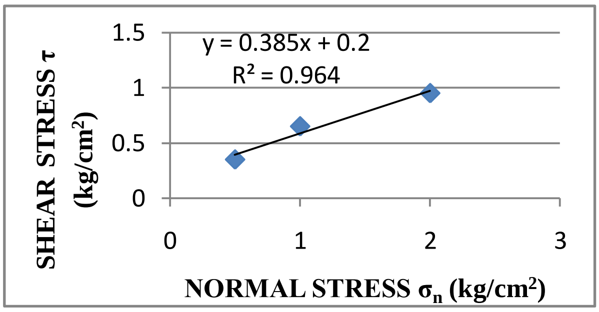

Fig.10: Direct shear test for SOFT MURRUM
C = 0.2
$\Phi = 21.09^o$

2.3.5 Hard Murrum: With Geomembrane

Table .6: Direct shear test for Hard Murrum

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)
0.5	0.4
1.0	0.75
2.0	1.25

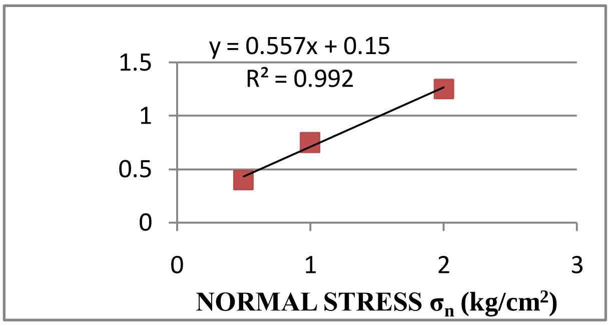

Fig.11: Direct shear test for HARD MURRUM

C = 0.15

Φ = 29.12°

2.3.6 Black Cotton Soil: With Geomembrane

Table .7: Direct shear test for Black cotton soil

Normal Stress (kg/cm^2)	Shear Stress (kg/cm^2)
0.5	0.30
1.0	0.45
2.0	0.75

III. Results and Discussion:

The earth pressure is calculated by static and dynamic methods, which is tabulated as below

Table .8: Comparison of Static and Dynamic earth pressure for different method and different soil

Sr. No	Type of soil	Static earth pressure (Analytical)		Static earth pressure (Graphical)		Dynamic earth pressure		PERCENT AGE DIFF. (%)
		RANKINE	COULOMB	PONCELETE	CULMANNS	M-O METHOD	IS CODE METHOD	
1	Soft murrum	142.236	138.024	139.6	138	152.265	141.32	9.35
2	Hard murrum	111.78	109.512	106.417	109	121.62	115.37	9.96
3	Black cotton soil	185.976	182.412	186.714	182.5	204.167	176.34	10.66

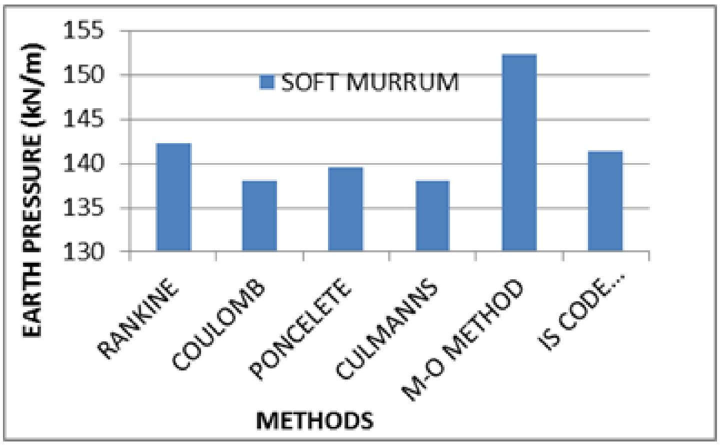

Fig.12: Earth pressure of soft murrum for different Method

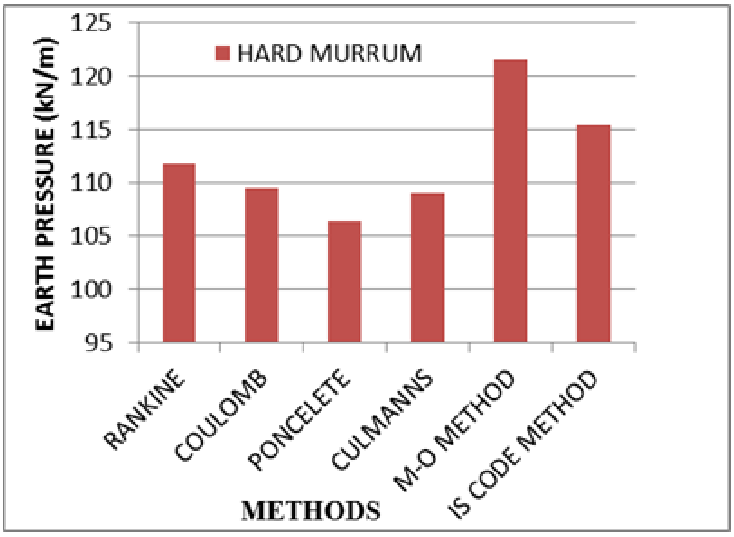

Fig.13: Earth pressure of hard murrum for different Method

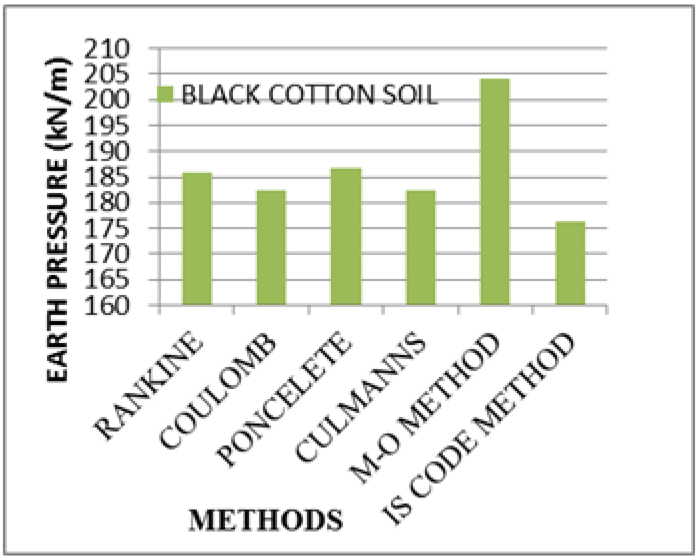

Fig.14: Earth pressure of black cotton soil for different method

IV. Conclusion:-

1 If a retaining wall is subjected to above backfills (soft murrum, hard murrum, black cotton soil) the earth pressure obtained by seismic case higher than static cases.
2. In the present work mononobe-okabe (dynamic earth pressure) method gives highest earth pressure for all types where as coulomb earth pressure is lowest earth pressure
3. If the backfills is soft murrum then rankine's and IS code method gives approximately same earth pressure.
4. The percentage difference between static and dynamic earth pressure is approximately same for all three backfills viz. soft murrum, hard murrum black cotton soil.
5. The percentage difference between static and dynamic earth pressure ranging between 9.35 to 10.66%

V. Limitations:-

1. The present works consist only three kinds of backfills viz. soft murrum, hard murrum, black cotton soil.
2. To evaluate dynamic earth pressure. The current research used only equivalent static load analysis which is approximately method.
3. Hence, other types of soils the current research work will not applicable.

Future scope:

1. The response spectrum analysis and linear time history analysis can be incorporated while evaluate dynamic earth pressure.
2. The MATLAB programming can be developed for current work.

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