International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

Evaluation of Dynamic Increment Component of Earth Pressure behind the Retaining Walls.

A.D.Maskar[1], S.N.Madhekar[2], D.R.Phatak[3]

[1]*Research Scholar, Dept. of Civil Engineering, College of Engg Pune (amol.maskar5@gmail.com)*
[2]*Associate Professor, Applied Mechanics, College of Engineering Pune (snm.civil@coep.ac.in)*
[3]*Adjunct Professor, Dept. of Civil Engineering, College of Engineering Pune (drp@coep.ac.in)*

Abstract -Retaining wall is one of the important structures in Civil engineering. During earthquake loading, earth pressure gets increased and those walls may fail due to excess deformation if these walls are not designed for earthquake. Retaining wall damages are ubiquitous throughout previous earthquakes such as the Northridge, Sichuan, Loma Prieta, Chi-Chi and L'Aquila in Central Italy etc. At present there are many methods available to evaluate earth pressure behind retaining walls in static and dynamic conditions. However these methods do not incorporate the effect of wall movement on the earth pressure. Dubrova was the first who considered such effect to evaluate active earth pressure behind walls. Till date, Dubrova's method is used for cohesion less soil, without considering the effect of seismicity. The current paper briefly explains the method of calculation of dynamic increment component of earth pressure which have been introduced in revised IRC:6-2014. Theory behind the formulae is given in IS:1893-1984 pertaining to dynamic increment. In the current study, the dynamic increment component has been evaluated by M-O method, PLAXIS solution, Dubrova's method and IRC:6-2014 code. IRC:6-2014 code shows parabolic dynamic increment distribution behind the retaining walls with zero intensity at top and bottom of the wall. The maximum dynamic increment is 10.96 kPa according to Dubrova's method whereas it is 11.61 kPa according to IRC:6-2014. Hence, Dubrova's method gets validated.

Keywords - Dubrova's method, Retaining wall, IRC, Dynamic increment, PLAXIS, M-O Method.

I. INTRODUCTION

Retaining wall is a very important structure in the field of civil engineering. It is used to retain backfill, at bridge abutment, embankment, basement etc. Presently there are various types of retaining walls used like cantilever, counterfort, and buttress retaining walls. The Retaining walls have failed either by sliding away from backfill or due to combined action of sliding and rocking displacement, during earthquake like Bhuj earthquake and Niigata earthquake. Hence, for the design of retaining walls it is necessary to incorporate the effect of the seismicity.

II. THEORY

The performance of retaining wall during earthquake is very complex. Due to repetitive nature of dynamic load of earthquake, there is need to determine displacement of wall due to earthquake forces and distribution of backfill soil mass. Laboratory test and analysis of such walls by Kramer (1996) indicated the following:

- Retaining walls can move by translation or rotation. The relative amount of translation and rotation depends on geometry, types of retaining walls and sub soil conditions.

- The magnitude and distribution of dynamic wall pressure are influenced by the mode of wall movement, e.g translation and rotation about base.
- The maximum soil thrust acting on a wall generally occurs when the wall has translated or rotated towards the backfill whereas the minimum soil thrust acting on a wall generally occurs when the wall has translated or rotated away from the backfill.

The BIS code IS:1893-1984 gives direct formula for treatment of dynamic increment of earth pressure. The distribution factor (K_d) is given by ratio of lateral dynamic increment in active pressures to the vertical pressures at various depths along the height of wall H as shown in Fig.2. The pressure distribution of dynamic increment in active earth pressure may be obtained by multiplying the vertical effective pressures by the coefficient K_d at corresponding depths.

$$Kd = \frac{\text{Lateral Dynamic Increment due to backfill}}{\text{Vertical Effective Pressure}}$$

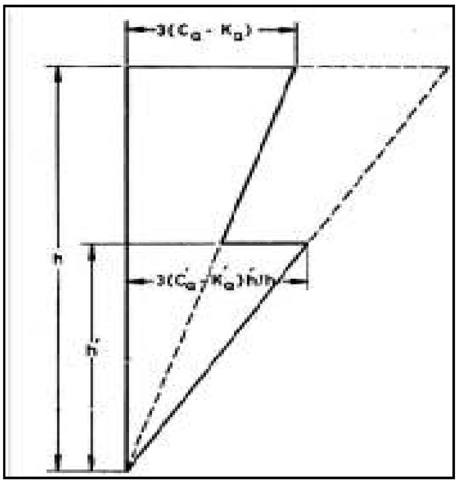

Figure 1.Distribution Factor Kd (IRC:6-2014)

Fig.2 shows the typical earth pressure diagram showing static and dynamic increment pressures. These diagrams with generic formula will help designers to draw pressure diagrams for even layered soils with different soil properties along the height of wall.

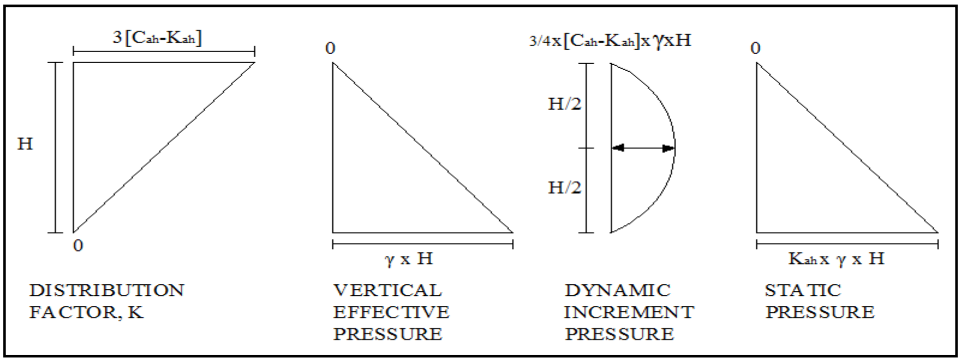

Figure 2.Distribution of Static and Dynamic Earth Pressure with Height of Wall (Bhowmick A., 2014)

III. FORMULATION OF THE PROBLEM

Dubrova (1963) was the first researcher who incorporated the effect of wall movement in computation of earth pressure in static case. Dubrova's method is also called method of redistribution of pressure. So it is necessary to form Dubrova's model in seismic condition. Hence, in this paper Retaining wall is analyzed by Dubrova's method with considering earthquake effect by response spectra method situated in zone V which is very severe zone. Hence, at a very sever zone, the retaining wall can be design. The dynamic increment component of earth pressure based on IRC:6-2014 needs to be checked with available methods.

IV. DUBROVA'S MODEL FOR EARTHQUAKE

According to Dubrova, there are an infinite numbers of failure planes exist in the backfill of the retaining walls. Considering failure plane only one of them. The various forces acting on failure plane is shown in Fig.3.

Let α = Horizontal earthquake coefficient.

P_d = Force inclined to horizontal at δ.

From the force polygon shown in Fig.3, the weight of wedge is given by,

$$W'd = Wd\sqrt{1 + \alpha^2 + 2\alpha\cos(90)}$$

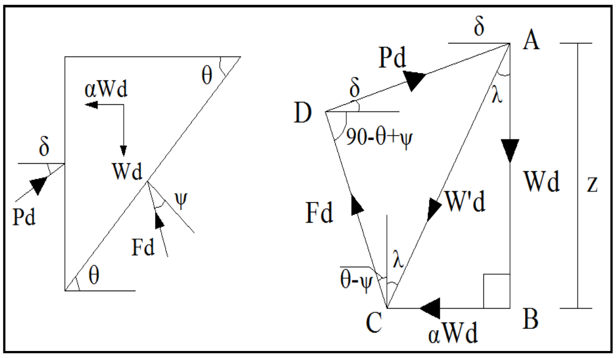

Figure 3.Trial Wedge of Retaining Wall and Force Polygon

$$P = \frac{\sqrt{1+\alpha^2}\ \gamma \cos\psi z[\cos(\psi-\lambda+\delta)+\sin(\delta+\lambda)]}{2\sin^2\left(45+\frac{\psi}{2}\right)\left[\cos\left(\frac{\psi}{2}+\delta\right)+\sin\left(\frac{\psi}{2}+\delta\right)\right]^2} \qquad \text{Eq. (1)}$$

The Eq. (1) gives the value of pressure distribution behind Retaining wall according to new Dubrova's model.

V. ILLUSTRATIVE DESIGN EXAMPLE

A Retaining wall (height=10m, unit weight of backfill is 18 kN/m^3 and angle of internal friction (ϕ) is 30^0 and angle of wall friction (δ) is 20^0) is analyzed by various methods, viz. M-O method, PLAXIS solution Dubrova's model and IRC:6-2014 code.

The solid retaining wall is almost rigid and no differential displacement shall take place in the wall during seismic acceleration. Hence, the wall is taken as zero period structure and the spectral acceleration coefficient of the wall is taken as 1.00.

Substituting the values of α_v is obtained as 0.12. Also, the vertical acceleration coefficient α_v = (2/3)*0.12 = 0.08

VI. RESULTS AND DISCUSSION

Based on soil parameters, the earth pressure coefficients in both statics and seismic cases are as below:

K_a=0.296; $K_{ah} = K_a \cos\delta = 0.278$; $K_{av} = K_a \sin\delta = 0.102$,
C_a=0.410; $C_{ah} = C_a \cos\delta = 0.384$; $C_{av} = C_a \sin\delta = 0.140$.

Table 2.Evaluation of Dynamic Increment of Earth Pressure by IRC:6-2014

Depth of Wall h (m)	Distribution Factor $k=3(C_{ah}-K_{ah})*h/10$	Vertical Effective Pressure $\sigma v' = \gamma_d * h1$	Dynamic Increment Pressure $k*\sigma v'$	Static Pressure $k_{ah}*\sigma v'$
0	0.258	0	0	0
1	0.2322	18	4.1796	5.022
2	0.2064	36	7.4304	10.044
3	0.1806	54	9.7524	15.066
4	0.1548	72	11.1456	20.088
5	0.129	90	11.61	25.11
6	0.1032	108	11.1456	30.132
7	0.0774	126	9.7524	35.154
8	0.0516	144	7.4304	40.176
9	0.0258	162	4.1796	45.198
10	0	180	0	50.22

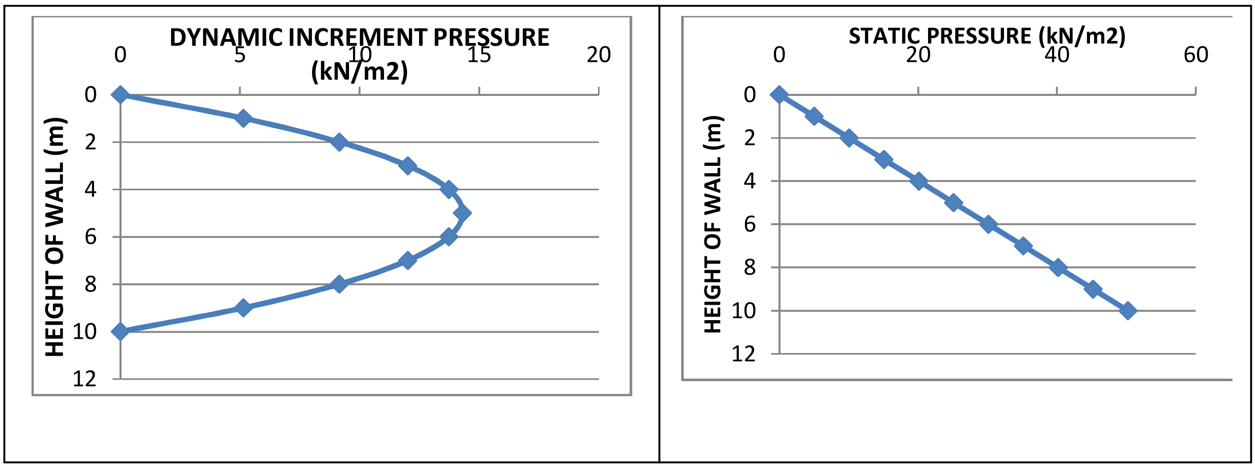

Figure 7.Dynamic Increment and Static Pressure behind the Retaining walls

Table 3. Dynamic Increment of Earth Pressure with Different Approaches

Depth of Wall h (m)	Dynamic Increment of Earth Pressure (kPa)			
	M-O Method	PLAXIS Solution	Dubrova's Method	IRC:6-2014
1	2.7	5.637	1.62	4.1796

2	5.399	10.994	3.116	7.4304
3	8.099	13.329	4.492	9.7524
4	10.798	18.823	5.749	11.1456
5	13.497	20.48	6.892	11.61
6	16.197	22.98	7.923	11.1456
7	18.897	24.171	8.844	9.7524
8	21.596	25.318	9.657	7.4304
9	24.296	26.669	10.363	4.1796
10	26.995	28.681	10.965	0

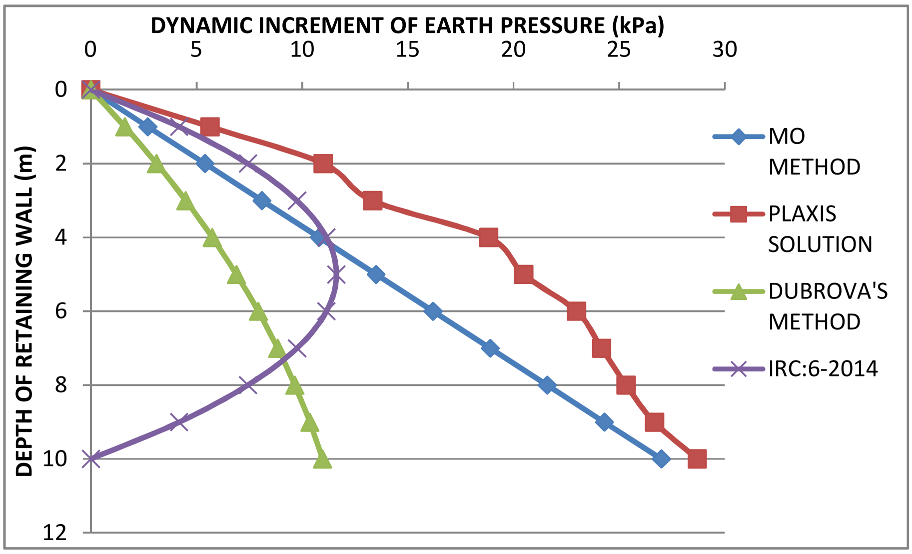

Figure 8.Variation of Dynamic Increment of Earth Pressure

CONCLUSIONS

From the various literature s, IRC:6-2014 and proposed Dubrova's model, the following conclusions are made.

1. IRC:6-2014 code shows parabolic dynamic increment distribution behind the retaining walls with zero intensity at top and bottom of the wall.
2. The MO method and PLAXIS solution shows linear distribution of dynamic increment for dry backfill
3. Dubrova's method gives parabolic variation maximum at the bottom.
4. The maximum dynamic increment is 10.96 kPa according to Dubrova's method whereas it is 11.61 kPa according to IRC:6-2014.
5. Hence proposed Dubrova model gives exactly similar results as that of IRC:6-2014.
6. The current study can be extended for different cases of backfills like partially submerged soils and uniform surcharge.

REFERENCES

[1] Bang, S. (1985) "Active Earth Pressure Behind Retaining Walls," Journal of Geotechnical Engineering, ASCE, Vol. 111 , No. 3, pp. 407-412.

[2] Bhowmick A., (2014) "Simplified Method of Calculation of Dynamic Increment Component of Earth Pressure & Live Load Surcharge for Bridge Abutments and Retaining Walls", Journal of Indian Road Congress, pp.263-269.
[3] Phatak, D. Vistasp M Karbhari, Anil S Paranjpe. (1987) "Discussion on active Earth Pressure Behind Retaining Walls" Journal of Geotechnical Engineering, ASCE, Vol. 113 , No. 4, pp. 932-933.
[4] G.A. Dubrova, (1963), Interaction between Soils and Structures [in Russian], "Rechnoi Transport"
[5] Harr, M. E. (1966), Foundations of Theoretical Soil Mechanics, McGraw-Hill Book Co., New York, N.Y.
[6] Bang, S. and Kim H. T. (1986) "At-Rest to Active Earth Pressure Transition." In Transportation Research Record, TRB, National Research Council, No. 1105, 41-47, Washington, D.C.
[7] Bang, S. and Kim, H. T. (1987) "Passive Lateral Earth Pressure Development Behind Rigid Walls." In Transportation Research Record, TRB, National Research Council, No. 1129, 63-67, Washington, D.C.
[8] Fang,Y, and Ishibhishi,I, (1986) "Static Earth Pressure with Various Wall Movements", Journal of Geotechnical Engineering, ASCE, Volume 112, No. 3, pp.313-333.
[9] Maskar A., Madhekar S., Phatak D., (2014), "Application of Dubrova's Method for Cohesionless Backfill under Seismic Condition." Structural Engineering Convection (SEC-2014).
[10]Firas A. Salman, Yousif J. Al-Shakarchi, Husain M. Husain and Dunya K. Sabre, (2010), "Distribution of earth pressure behind retaining walls considering different approaches" International Journal of the Physical Sciences Vol. 5(9), pp. 1389-1400.

