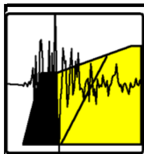


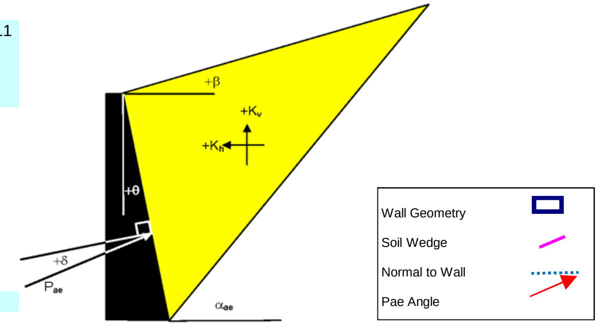
MONONOBE - OKABE AND COULOMB EQUATIONS

prepared by Geo-Struct Sparks, LLC www.geostructsparks.com

Mononobe-Okabe and Coulomb Equation
Sign Convention and Geometry

ver 2011-11-20

Project:	Retaining Wall	Calc By:	11/15/2011
Proj. No.:	123456	Checked:	
Case:			



Metric or English Units (M/E) E **M or E**

Coulomb or Rankine Analysis COULOMB ANALYSIS

STRUCTURE AND SLOPE GEOMETRY

Angle of Slope at Top of Wall from horizontal	26.56	β, degrees	0.463559 radians
Back of wall angle (batter) from vertical	15	θ, degrees	0.261799

SOIL STRENGTH AND PROPERTIES

Friction Angle	34	ϕ, degrees	0.593412
Pa rotation relative to normal to wall	15.0	δ, degrees	0.261799

EARTHQUAKE ACCELERATION

EQ kh* Typ. use 1/2 of max horiz acceleration for active walls, 1.5 x max accel for tiedback or batter pile walls(AASHTO, 1998 Div 1A Sect 7.4.3A) — 0.1 decimal g (Comment)

EQ kv, most design methods permit leaving kv as zero — 0 decimal g — 0.099669 ψ, radians

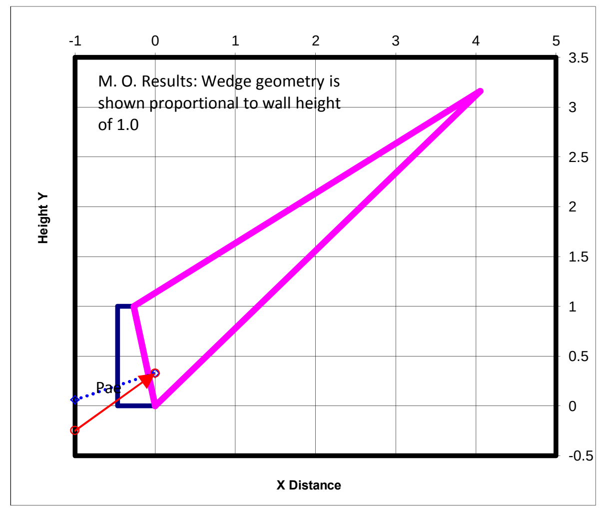
DISPLACEMENT BASED DESIGN

Design peak acceleration for Site (>k_h)	0.4	A, decimal g (actual A, not k_h = 1/2 A typically used)
Design peak velocity, Normalized by A (FHWA value:)	760	V/A (mm/s) use 760 if not evaluating EQ records
Design peak velocity for Site	12.0	in/s

For information on input parameter selection, go to http://www.geostructsparks.com/parameterguide.htm

Franklin & Chang (1977) Estimate Upper Bound Residual Displacement: 11.1 inches

data from Newmark modeling from actual time histories -an approximation recommended by FHWA



$$K_a = \frac{\cos^2(\varphi-\theta)}{\cos^2(\theta)\cos(\delta+\theta)\left[1+\sqrt{\frac{\sin(\varphi+\delta)\cdot\sin(\varphi-\beta)}{\cos(\delta+\theta)\cdot\cos(\beta-\theta)}}\right]^2}$$

Numerator 0.894005; Denominator 1.44953; 0.62

$$K_{ae} = \frac{\cos^2(\varphi-\psi-\theta)}{\cos(\psi)\cos^2(\theta)\cos(\delta+\theta+\psi)\left[1+\sqrt{\frac{\sin(\varphi+\delta)\cdot\sin(\varphi-\psi-\beta)}{\cos(\delta+\theta+\psi)\cdot\cos(\beta-\theta)}}\right]^2}$$

Numerator 0.94716; Denominator 1.030514; 0.92

$$K_p = \frac{\cos^2(\varphi+\theta)}{\cos^2(\theta)\cos(\delta-\theta)\left[1-\sqrt{\frac{\sin(\varphi+\delta)\cdot\sin(\varphi+\beta)}{\cos(\delta-\theta)\cdot\cos(\beta-\theta)}}\right]^2}$$

Numerator 0.430413; Denominator 0.030545; 14.09

$$K_{pe} = \frac{\cos^2(\varphi-\psi+\theta)}{\cos(\psi)\cos^2(\theta)\cos(\delta-\theta+\psi)\left[1-\sqrt{\frac{\sin(\varphi+\delta)\cdot\sin(\varphi-\psi+\beta)}{\cos(\delta-\theta+\psi)\cdot\cos(\beta-\theta)}}\right]^2}$$

Numerator 0.529838; Denominator 0.03859; 13.73

$$F_1 = \tan(\varphi-\psi-\beta)$$ F1 0.030193

$$F_2 = \cot(\varphi-\psi-\theta)$$ F2 4.233794

$$F_3 = \tan(\delta+\theta+\psi)$$ F3 0.718853

$$\alpha_{ae} = (\varphi-\psi) + \operatorname{atan}\left\{\frac{\sqrt{F_1(F_1+F_2)(1+F_3F_2)}-F_1}{1+F_3(F_1+F_2)}\right\}$$ 37.9 degrees

References:

Kae and αae: FHWA, 1998, Geotechnical Earthquake Engineering, FHWA-HI-99-012

Franklin A.G., and F.K. Chang, 1955, Earthquake Resistance of Earth and Rock-Fill Dams, Report 5: Permanent Displacement of Earth Embankments by Newmark Sliding Block Analysis, Misc. Paper 5-71-17, Soils and Pavements Laboratory, US Army Engineers Waterways Experiment Station, Vicksburg Mississippi.

Active Earth Pressure Coef., K_{ae}	**0.92**	**Coulomb Ka (static)**	**0.62**
ΔK_{ae}	**0.30**		
Failure Angle α_{ae}	**37.9**		
Kae Horizontal Compnt	**0.80**		
Passive Earth Pressure Coef., K_{pe}	**13.73**	**Coulomb Kp (static)**	**14.09**

Unit Weight:	125	units:	pcf
P_{ae}	114.9	Pa	77.1
ΔP_{ae}	37.8		
P_{aeh}	99.5		
P_{pe}	1716.2	Kp	1761.4