Particular Concepts

Activity 9

"Concept of Applied Rankine Active Force"

by William J. Spry, PhD Nuclear Physics

A Rankine material is defined as a composite of particles which interact solely by the frictional forces between them. As a consequence -- under the influence of gravity -- a pile of such material can be formed on a flat, horizontal surface. The angle that the top surface of that pile makes to the supporting plane surface is directly related to the average coefficient of friction among the particles in the composite. It is generally identified as the angle-of-repose: the greater the angle, the greater the average friction between particles.

If the inter-particle frictional forces are essentially zero (such as in ball bearings), no pile is formed (the angle-of-repose becomes zero). If the inter-particle frictional forces are very high (such as in irregular, freshly crushed dry sand) the material is rapidly contained and the angle-of-repose approaches ninety degrees.

Figure #1 shows this relationship with Rankine material restrained by a retaining wall consisting of flat plates supported by vertical posts. Consider the forces to the left and right of the Reference Plane. In the upper and lower sections (A), the material has flowed to the right of the Reference Plane until the Rankine active force is constrained by the sloping pile of material (at the Rankine material's angle-of-repose). The force "Out" on the Piston in the middle section is this same Rankine active force (here restraining particle flow). The "Motive and Retentive Particulate Force Table" calculates Rankine active forces, dependent on the particulate used.

If the Rankine material had essentially zero internal friction between particles (such as ball bearings), the force to move the Piston "In" would be the same as that attempting to move the piston "Out". This would be normal hydraulics. However, the internal friction between the particles of normal Rankine material (such as in various dry sands) must be overcome to move the Piston "In". This force, also calculated by Rankine, is the Rankine passive force. Due to this internal friction between particles the Rankine passive force is opposite to, and greater than the Rankine active force. All the activities of the Particular Concepts manual involve Rankine Active Forces.

The Spry patents and the Particular Concepts activities are applications of the Rankine Active Force.

(References: Rankine, J. B. (1857), "On the Stability of Loose Earth," Philosophical Transactions of the Royal Society of London, Vol. 147, Part 1, pp. 9-27; Braja M. Das, Advanced *Soil Mechanics*, Second Edition, California State University)

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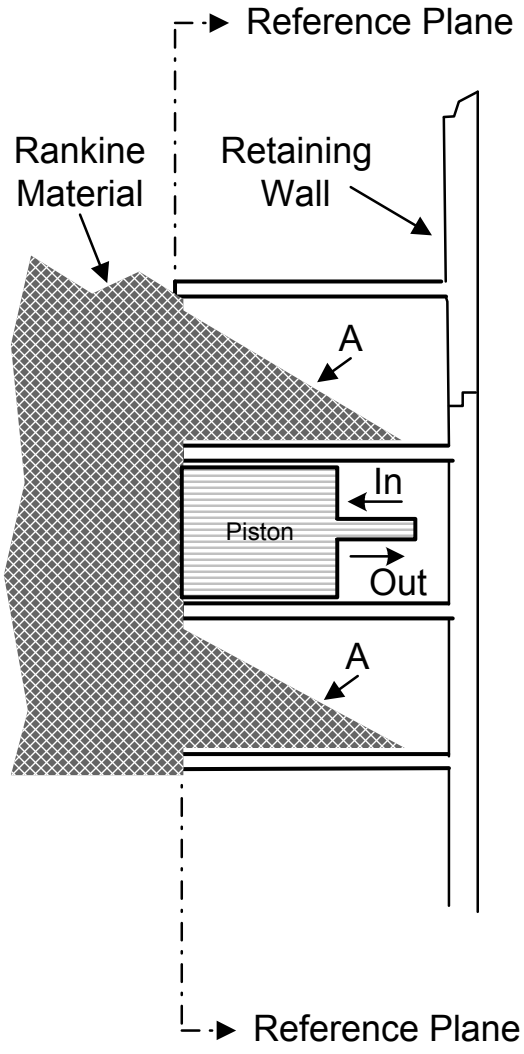
"Concept of Applied Rankine Active Force"
continued

Figure #1:



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Activity 9

Motive and Retentive Particulate Force Table

The Rankine Active Force For a Free Standing Particle Pile 1

2	B	C	D	E	F	G	H	I	J	K	L
3	Density =	1	lbs/cu.ft.	For a different density, multiply the force times the different density.							
4	Width =	1	ft.	For a different width, multiply the force times the different width.							
5				For a different density and width, multiply the force times both! (Compare Chart 1 to Chart 2)							
6	Angle of Repose = Ø		Degrees								
7											
8	Excel Formula for 1 foot high at 90 degrees:				C4*C3*((C$14*C$14)/2)*(TAN(PI()*((45-($B16/2))/180)))*(TAN(PI()*((45-($B16/2))/180)))						
9	OR										
10	F=WxDx Integral{z(dz)((Tan(45-Ø/2)) squared)}										
11											
12	W= width in feet		z=depth in feet		D=density in lbs per cubic foot						
13											
14	H(feet)	1	2	3	4	5	6	7	8	9	10
15	Ø(degrees)										
16	90	**0.00000**	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	80	0.00383	0.01531	0.03444	0.06123	0.09568	0.13778	0.18753	0.24494	0.31000	0.38271
18	75	0.00867	0.03466	0.07800	0.13866	0.21665	0.31198	0.42464	0.55464	0.70196	0.86662
19	70	0.01555	0.06218	0.13991	0.24873	0.38864	0.55964	0.76173	0.99492	1.25919	1.55456
20	65	0.02457	0.09830	0.22117	0.39319	0.61436	0.88467	1.20414	1.57275	1.99052	2.45743
21	60	0.03590	0.14359	0.32309	0.57437	0.89746	1.29234	1.75902	2.29750	2.90777	3.58984
22	55	0.04971	0.19883	0.44736	0.79531	1.24267	1.78944	2.43563	3.18123	4.02624	4.97067
23	50	0.06624	0.26495	0.59613	1.05979	1.65593	2.38454	3.24562	4.23918	5.36521	6.62372
24	45	0.08579	0.34315	0.77208	1.37258	2.14466	3.08831	4.20354	5.49033	6.94870	8.57864
25	40	0.10872	0.43489	0.97849	1.73954	2.71804	3.91397	5.32735	6.95817	8.80643	10.87214
26	35	0.13550	0.54198	1.21946	2.16792	3.38738	4.87782	6.63926	8.67168	10.97510	13.54950
27	30	0.16667	0.66667	1.50000	2.66667	4.16667	6.00000	8.16667	10.66667	13.50000	16.66667
28	25	0.20293	0.81172	1.82636	3.24687	5.07323	7.30545	9.94353	12.98747	16.43727	20.29293
29	20	0.24515	0.98058	2.20631	3.92232	6.12863	8.82523	12.01212	15.68930	19.85677	24.51453
30	15	0.29440	1.17758	2.64956	4.71033	7.35988	10.59823	14.42537	18.84130	23.84602	29.43954
31	10	0.35204	1.40818	3.16840	5.63271	8.80110	12.67359	17.25016	22.53082	28.51557	35.20441
32	5	0.41983	1.67933	3.77848	6.71730	10.49579	15.11393	20.57174	26.86921	34.00634	41.98314
33	0	0.50000	2.00000	4.50000	8.00000	12.50000	18.00000	24.50000	32.00000	40.50000	50.00000