

https://dspace.org/

Properties of weakly cemented slurries of gold mine slimes

Avalle, Derek Luigi

2014-10-15
http://hdl.handle.net/10539/15745

Downloaded from a DSpace repository. https://dspace.org/

Considering a practical situation where liquefaction failure occurs, the consequence might be that any strength that had developed in the slimes mix could be lost, and the material, particularly at the edges where moisture contents are usually higher, will be in a state of potential flow. The original retaining structure which was necessary to retain the slurry during placing will thus still have to be adequate to retain any liquefied material even after it has been deformed by stope closure.

If liquefaction does occur due to blasting or earthquake vibrations, it is likely to be of a temporary nature because the prevailing drainage conditions will probably allow relatively rapid dissipation of the excess pore water pressures developed at liquefaction. By the time liquefaction occurs, some water should have already drained from the fill mass, which means that the redevelopment of strength will take place under improved conditions because of the preliminary densification.

Some previous cyclic triaxial tests have been conducted at higher frequencies[8,10] than were used above. It is possible that the use of loading frequencies more representative of blasting or earthquake vibrations might produce different effects on the material, such as larger pore pressure increases. Further research in this direction might lead to a better understanding of the liquefaction problem. Practical tests to examine the occurrence and effects of liquefaction might also provide valuable information about this problem.

6. SUMMARY OF CONCLUSIONS

The one property of the slimes which was found to have most repercussions on other properties was its particle size distribution. In comparing the coarser and the finer slimes, it was shown that the coarser material:

a) required a lower minimum moisture content for pumpability,

b) exhibited stronger dilation and excess pore pressure reduction phenomena during static triaxial loading,

c) exhibited a steeper drained shear strength envelope in terms of effective stress,

d) exhibited improved strength development properties in both laterally-unrestrained and fully-restrained situations, and

e) displayed a decreased potential for liquefaction failure.

Turning to the stabilising agents and their different effects on the mixes, as compared with the standard mix including portland cement, it was shown that:

a) mixes including cement and power station flyash can improve both shear strength and strength development properties for a lesser proportion of cement, and

b) hydrated road lime as a cementing agent compares favourably with cement when the lime is used in combination with flyash and small amounts of phospho-gypsum, the lime being used in a smaller proportion than the standard proportion of cement.

The effects of lateral restraint on strength development properties showed that:

a) the inclusion of even a small area proportion of reinforcement spanning in only one direction was beneficial,

b) the inclusion of larger proportions of reinforcement might be beneficial to early strength development,

c) full lateral restraint was most beneficial, but the magnitudes of horizontal stress developed would require a very substantial retaining structure or excessive amounts of reinforcement which would probably be uneconomical, and

d) even in the case of full lateral restraint, cementing agents had a beneficial effect on strength development.

Finally, from the practical side, the use of weakly cemented slimes slurries underground appears feasible. Further research could see the development of theories or design criteria for strength requirements. The monitoring of trial applications underground could be of great advantage. The liquefaction phenomenon, its occurrence and its prevention, also require further study. Technicalities such as the type of confining structure and its placement in the stope (overseas applications have invariably been in confined spaces), require investigation and experimentation. In these times of waste, pollution and preservation consciousness, further research into the economic and useful utilisation, in large quantities, of waste materials such as gold mine slimes and power station flyash should be easily motivated.

POSTSCRIPT

In January 1976, a visit was paid to Stilfontein Gold Mine to observe their first efforts in pumping and placing cemented slimes slurry in a working stope. The site of the backfilling was about 1 700 m below ground level in a stope of average depth 1 m.

The pumping station was situated about 550 m from the fill area. The slurry, consisting of SGM slimes (fine grey slimes obtained directly from the reduction filters) with about 10% cement and approximately 54% moisture content, was pumped about 500 m horizontally and then up a 45° incline to the stope. The retaining structure for the slurry was made of a woven polypropylene cloth glued to the floor and ceiling of the stope. Outside of the plastic, additional support was provided by wire mesh, and wooden poles at roughly 1 m centres supported old wire cables strung internally across the structure. The outer dimensions were about 10,8x3,6 m, and the situation is depicted in Fig. 9. The blast face at placement of the fill was no more than 4 m from the fill.

At the time of inspection, the fill was about 50 days old. Blasting had proceded, the blast face retreating to about 8 m from the fill, and there was no evidence of any damage or problems caused by the blasting. Some amount of closure in the stope was evident as a few support poles had crushed. The retaining structure showed no other signs of failure. Senior personnel at the mine estimated that with traditional timber-stack supports, the stope would have closed fully

about 5 months after mining of the stope. The behaviour of the fill area during this period will be monitored by the mine staff.

During the visit, in situ shear strength tests were conducted with a VT 400 Shear Vane. The tests were done at about mid-depth in the fill and at about the centre of each of the opposite longer sides. A small area of the woven cloth retaining structure was removed, and shear vane tests were done at various depths in the fill. The results are shown in Fig. 32.

The results of the tests, as well as observations made of the trial fill, show that the material is reasonably well cemented. The increase in shear strength towards the centre of the fill,shown in Fig. 32, indicates that a reduction in moisture content towards the centre of the fill has taken place although the closure of the stope at this time was small.

An assessment of the principal stresses acting at the centre of the fill can be made as follows:

From Fig. 32, maximum shear stress $\approx$ 170 kPa

$$\text{or } \tfrac{1}{2}(\sigma_1-\sigma_3) \approx 170 \text{ kPa} \qquad (11)$$

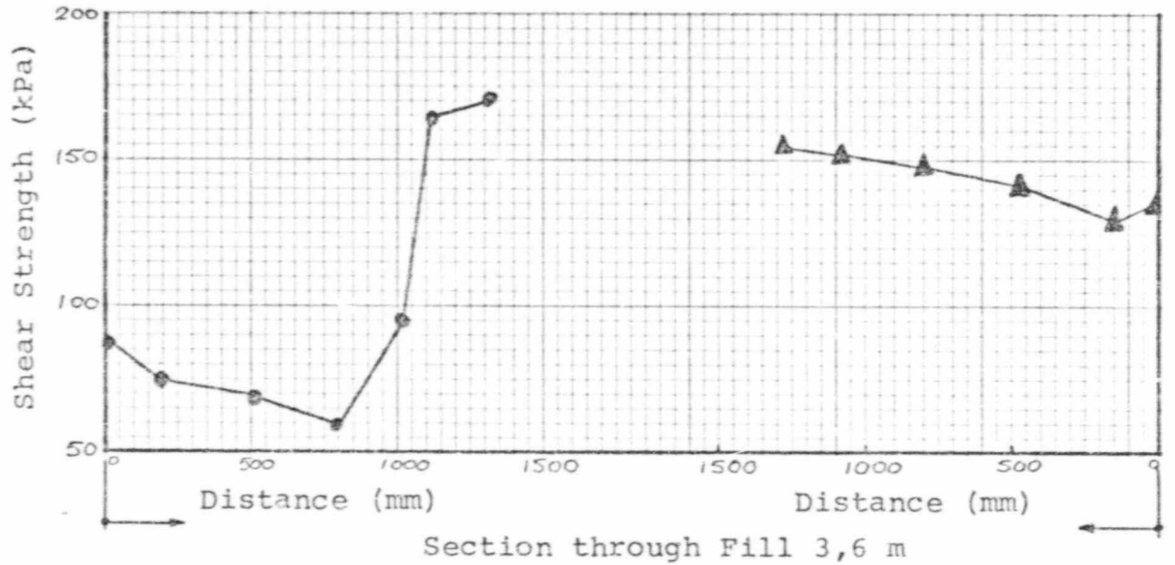
Then from the shear strength envelope (Fig. 15) for SGM slimes with 1:10 cement:slimes,

$$\tfrac{1}{2}(\sigma_1+\sigma_2) \approx 280 \text{ kPa} \qquad (12)$$

From (11) and (12)

$$\sigma_1 = 450 \text{ kPa}$$
$$\sigma_3 = 110 \text{ kPa}$$

Side Nearer
Blast Face



Side Away From
Blast Face

Fig. 32 Measured Shear Strength across Fill Section

This shows a compressive strength development of nearly 0,5 MPa, which is quite substantial considering the conditions in the stope and the small amount of closure experienced at that stage.

BIBLIOGRAPHY

1. Espley, G.H., Beattie, H.F., and Pasieka, A.R. *'Cemented Hydraulic Backfill within the Falconbridge Group of Companies'*. CIM Bulletin, Sept. 1970, pp. 1002-1010.

2. Thomas, E.G. *'Cemented Fill Practice and Research at Mount Isa'*. Aus. I.M.M. Conf. 1971, Paper No. 13, March 1971.

3. Waterfield, M.C. *'A Review of Fill Mining Practice'*. Dept. of Energy, Mines and Resources, Canada, Internal Report 73/95, June 1973.

4. Johnson, C.V. and Gisler, H.J. *'Preparation and Handling of Sand for Hydraulic Stope Filling'*. Denver Equipment Company Bulletin, No. G3-B66.

5. Weaver, W.S., and Luka, R. *'Laboratory Studies of Cement-Stabilized Mine Tailings'*. CIM Bulletin, Sept. 1970, pp. 988-1001.

6. McDowell, C. *'Stabilization of Soils with Lime, Lime-Flyash, and Other Lime Reactive Materials'*. Highway Research Board, Bulletin 231, Jan. 1959, pp. 60-66.

7. Beckwith, R.H., and Schnuir, N.D. *'The Stabilization of Soils with Flyash and Lime'*. Civ. Eng. Final Year Lab. Project, University of the Witwatersrand, 1975.

8. Lee, K.L., Seed, H.B., Idriss, I.M., and Makdisi, F.I. *'Properties of Soil in the San Fernando Hydraulic Fill Dams'*. Journal Geotech. Eng. Division, ASCE, Vol. 101, No. GT8, Aug. 1975, pp. 801-821.

9. Knight, K., and Blight, G.E. *'Studies of Some Effects Resulting from the Unloading of Soils'*. Proc. 6th Int. Conf. on Soil Mech., Vol. 3, Paper 22, 1965.

10. Martin, G.R., Finn, W.D.L., and Seed, H.B. *'Fundamentals of Liquefaction Under Cyclic Loading'*. Journal Geotech. Eng. Division, ASCE, Vol. 101, No. GT5, May 1975, pp. 423-438.

11. Bishop, A.W., and Henkel, D.J. The Measurement of Soil Properties in the Triaxial Test. London: Edward Arnold, 1957.

12. Blight, G.E. *'A Note on Field Vane Testing of Silty Soils'*. Canadian Geotech. Journal, Vol. v, No. 3, Aug. 1968, pp. 142-149.

13. Jaeger, J.C., and Cook, N.G.W. Fundamentals of Rock Mechanics. London:Methuen, 1969.

14. Carslaw, H.S., and Jaeger, J.C. Conduction of Heat in Solids, 2nd ed. London:Oxford Univ. Press, 1959.

Author Avalle Derek Luigi
Name of thesis Properties Of Weakly Cemented Slurries Of Gold Mine Slimes. 1976

PUBLISHER:

University of the Witwatersrand, Johannesburg
©2013

LEGAL NOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed, or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.