The Water-jet Penetration Test — A Field Test of Loess Erodibility

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SUMMARY The development of a water-jet penetration test for measuring the erodibility of loess is described. The advantages of the test as a rapid and reproduceable means of measuring erodibility are shown. Two applications of the test are given as examples.

1 INTRODUCTION

A number of tests exist to estimate the erodibility of loess. These tests include the qualitative or semi-quantitative examination of loess samples in the pinhole, drop, crumb, and field dispersion tests; and quantitative examination in chemical tests and surface flume tests. All of these tests require considerable laboratory and field time. Most of the tests are subjective and evaluate the occurrence of dispersion or slaking. None is performed in situ and they do not always simulate realistically the field conditions affecting erodibility. Little is known in quantitative terms of the areal distribution of erodible loess, and without the investment of excessive time and effort none of the current laboratory tests can give a sufficient number of measurements to determine the distribution. Because of this limitation and various procedural limitations of available tests, there is a need for a rapid, reproduceable field test for erodibility.

2 THE APPARATUS

The water-jet penetration apparatus, developed in 1978 at the University of Canterbury, comprises a high pressure air source driving water from a pressurised tank through a nozzle designed to give a fine laminar jet (see Figure 1). An alloy diving cylinder of 27 cubic metres capacity provides the air source. Air is fed via a pressure regulator to a stainless steel water reservoir at 689 KiloPascals. The 5 litre capacity water reservoir is designed for fast filling and has a pressure relief valve. A WEBSTER Model "147" air dusting gun controls the water flow, which is also at 689 KiloPascals. A 0.6 millimetre welding nozzle attached to the gun gives a fine liminar jet of water. The apparatus is mounted on a pack frame with a flat base enabling it to be placed upright on level terrain. The apparatus, when full, weighs approximately 23 Kilograms.

A measurement is made by aiming the water-jet normal to an in situ loess surface (see Figure 1) and the penetration is measured under standard conditions, including time of application, air pressure, and distance from the surface. A provisional set of standard conditions was established during a series of trials in 1978. The conditions optimise the erosive force of the jet and make efficient use of the capacity of the water reservoir. They are: duration of jet - 10 seconds; distance from nozzle tip to the loess surface - 100 millimetres; water pressure - 689 KiloPascals. Penetration is measured using a wire depth gauge and a millimetre rule (see Figure 1 inset).

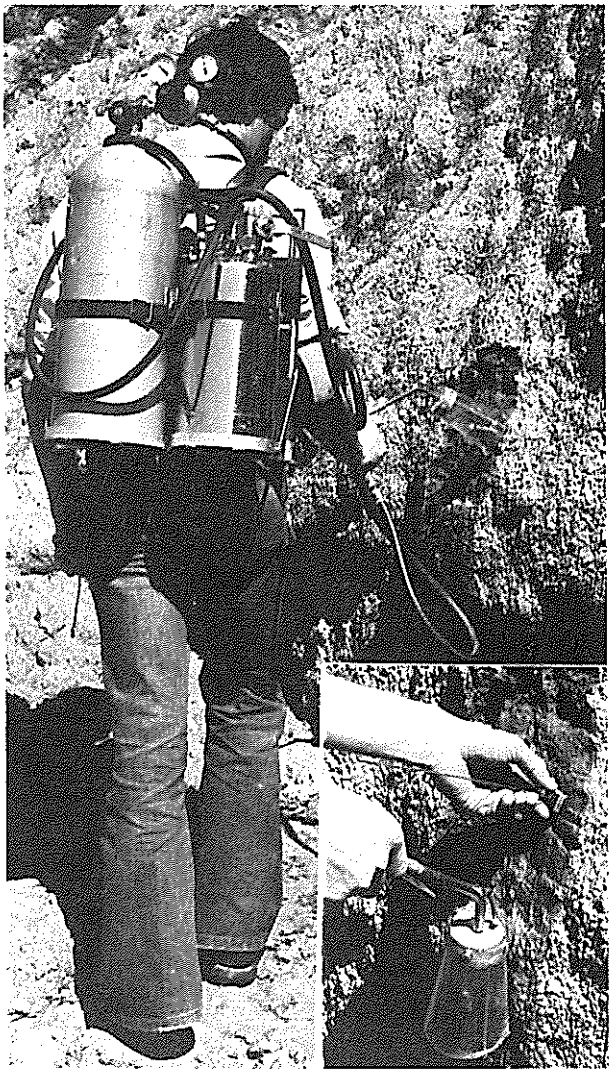

Figure 1 Apparatus in use, inset shows sample measurement

3 TWO APPLICATIONS

The water-jet penetration test was applied to a fresh-cut loess bank to see if layers of different erodibility in the loess profile could be distinguished. Eight groups of 15 measurements were made at 300 millimetre intervals down the bank. Five different penetration responses were distinguished at the 90 percent confidence level using the Mann-Whitney U-Test for non-parametric data. These different responses corresponded visually to identifiable layers in the loess profile. The water-jet penetration test thus showed there are layers in a loess profile with significantly different penetration values, which correspond to visual changes in loess character.

Another application tested the ability of the water-jet penetration apparatus to distinguish zones of different penetration resistance surrounding a subsurface tunnel. Ninety-two measurements were made on a grid pattern normal to the tunnel axis at its point of efflux. A contour diagram of the penetration data revealed zones of increased penetration, possibly associated with the tunnel opening. Further work is necessary to determine which loess properties are controlling water-jet penetration.

4 CONCLUSIONS AND FUTURE WORK

Preliminary investigations show that the water-jet penetration test could prove a satisfactory field test of loess erodibility. The test has the following characteristics:

a. It is a rapid test in which a sample measurement takes only seconds to obtain.

b. Very little, if any, laboratory work is required.

c. An *in situ* measure of loess characteristics is provided, and drill cores could be quickly tested if necessary.

d. The method has proved statistically valid and does not suffer from the limitations of low sample numbers as do many laboratory tests.

e. The test is a more objective approach to measuring loess erodibility than some other tests.

Future work will include an impirical examination of some of the geotechnical parameters which may control water-jet penetration in loess. These parameters include grainsize distribution and packing, water content, Atterberg Limits, clay mineralogy and exchangeable cations, and local factors such as lo loess type, slope angle, and aspect. A comparison will be made with existing erodibility tests.