J. agric. Engng Res. (1983) **28,** 479–484

RESEARCH NOTES

A Technique for the Non-destructive Monitoring of Subsurface Drains

P. B. Leeds-Harrison*; R. K. Fry*; C. J. Cronin*; J. E. Gregory†

A simple borescope technique for the non-destructive monitoring of mole channels and pipe drains is described. Requirements and specifications for a suitable borescope and ancillary equipment are discussed as well as practical considerations for field use. The fully portable equipment is shown to be successful in both long and short term evaluations of subsurface drain performance.

1. Introduction

There are many drainage situations where there is a requirement to monitor subsurface drains. Changes in drains may occur very rapidly and regular monitoring is required to allow the physical processes to be observed. Such changes are the collapse of mole drains, sedimentation and deformation of pipes.

For mole drains the current methods such as gypsum casting (see Nicholson[1] and Talman[2]) or plastic foam casting (Thorburn[3]) for observing changes to the mole channel involve destructive monitoring with the attendant problem of sampling at a different location from one sampling period to another. In addition such techniques can be very time-consuming which can be a deterrent to intensive monitoring.

The use of an industrial borescope overcomes these problems and allows non-destructive monitoring of drainage systems.

2. The borescope

A borescope, *Fig. 1*, is an optical device similar to a periscope but with integral light source, and is used widely in industry to inspect poorly accessible parts through small openings. For the observation of subsurface drains the following criteria were used in selecting the borescope.

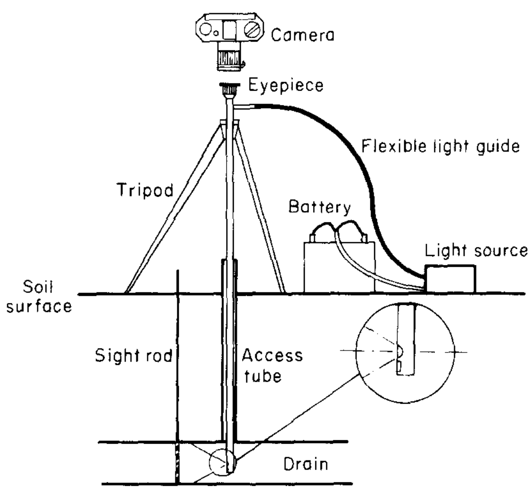

Fig. 1. General arrangement of the borescope in use in the field

*National College of Agricultural Engineering, Silsoe, Bedford MK45 4DT
†Ministry of Agriculture, Fisheries and Food, Land and Water Service

Received 9 February 1983; accepted in revised form 14 April 1983

0021–8634/83/050479 + 06 $03.00/0

(1) Instrument length must allow access to the drain while allowing easy access to the eyepiece.
(2) The diameter of the instrument should be considerably smaller than the diameter of the drain being observed, this will keep the access point small.
(3) The field of view of the instrument should match the drain size allowing the full cross-section of the drain to be observed. For vertical installation the borescope must have a 90° prism at the objective.
(4) The instrument with its associated light source should be portable and suitable for field work. The objective of the borescope should be waterproof.
(5) The instrument should be capable of allowing a photographic record to be made. This implies that the instrument must allow a camera attachment and be capable of being held rigidly.

The borescope and light source selected for drain monitoring were manufactured by KMI, and a compatible Olympus OM2 automatic camera with data back was used to photograph the channels. The borescope was 1025 mm long, 10 mm in diameter and the sealed stainless steel body contained a conventional glass lens system with 90° objective prism. The overall field of view was a 60° cone. The fan-cooled, focused halogen bulb light source gave 100 W at 10 A from a 12 V battery and light transmission to the borescope was by fibre optic bundle with intensity control.

3. Installation of access tube

The correct placement of an access tube is critical to the successful implementation of this technique. *Fig. 1* shows a typical installation of the borescope into a drain. A vertical plastic tube is placed so that it just enters the drain. For lined drains the technique described by Cavelaars[4] for installing piezometer tubes into tile drains is suitable for access tubes. A hole is augered to the drain and a pipe borer is used to cut a hole into the pipe wall. A rubber bung with the access tube is fitted into the bored hole (see *Fig. 2*). The auger hole is filled around the access tube with bentonite. This prevents direct movement of surface water into the drain, shortcircuiting the normal flow paths. Alternatively a tee-piece may be placed in the drain at installation with the tee vertical allowing access to the drain. For unlined mole channels, the installation technique must ensure that the drain does not become damaged during or as a result of installation of the access tube. The most satisfactory technique is to install the tube behind the leg of the mole plough between the foot of the mole plough and the expander. As the mole plough pulls forward the expander displaces soil around the tube leaving a smooth channel with the tube just entering it. A rod must be placed in the tube during this operation to prevent soil being pushed into the tube (see *Fig. 3*).

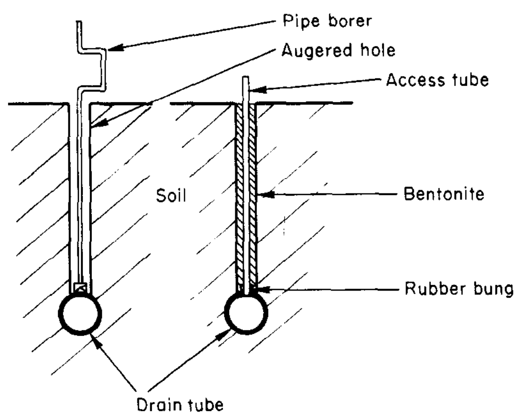

Fig. 2. Placement of an access tube into a tile drain using the technique described by Cavelaars[4] for the installation of piezometers

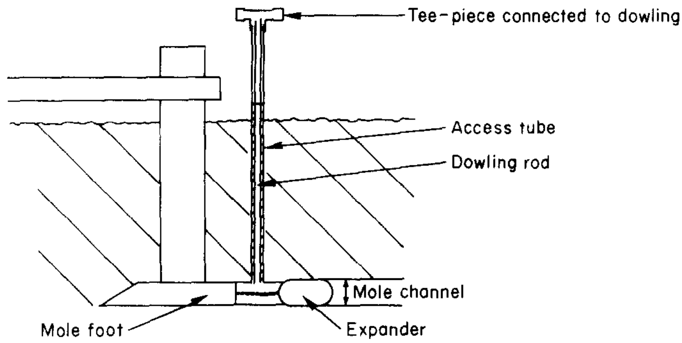

Fig. 3. Placement of an access tube behind a mole plough leg

In some cases, because mole drainage has been done at a previous time, it is necessary to install the access tube by augering into the mole channel. In this case a helical auger of the same diameter as the outside of the access tube is used. Augering proceeds, allowing the auger to draw itself into the soil, until it just enters the mole channel. The auger is then pulled upwards leaving an augered hole in which the access tube may be placed. This technique prevents excessive loading on the roof of the mole channel, which would tend to cause it to collapse. Where damage to the roof of the channel occurs at installation of the access tube a simple tool is used to compress soil around the bottom of the tube (see *Fig. 4*), thus locally reforming the channel.

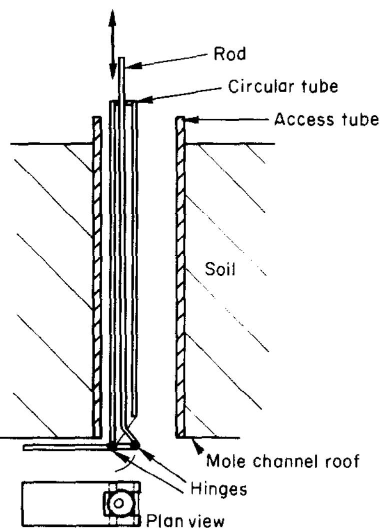

Fig. 4. Diagram showing a simple tool for reforming disturbed soil at the base of the access tube (not to scale)

4. Observations

Using a 12 V battery the light available at the objective lens allows approximately 0·4 m of drain to be observed in each direction. This distance is influenced by the reflectivity of the drain lining. A yellow plastic drain allows larger observation distances than a clay tile drain. If the angle of view is reduced to 30°, then longer distances can be observed.

It has also been found that contrast between daylight and the image received influences the clarity of the observation. Thus at night or with a hood over the instrument and observer, the image appears brighter than that seen on sunny days, with no hood.

A sight rod placed vertically in the drain (*Fig. 1*) acts as a reference and allows vertical drain dimensions to be estimated. Depth of silt in the drain can be read off the sight rod by marking the rod at 10 mm intervals. Similarly changes in vertical dimensions of mole channels can also be measured about a marked centre line.

Exposure times for photographic work range from 4 to 30 s with 60° angle of view, depending on film speed and drain reflectance. When taking photographs the camera must be held steady and the use of a camera tripod or borescope clamp is essential. Thorburn[5] has shown that the use of a 30° angle of view considerably increases exposure time as less light is reflected from channel walls.

Figures 5 and *6* show photographs taken in field drainage pipes. Silt can be clearly seen in the 80 mm diameter plastic pipe in *Fig. 5*. In *Fig. 7* the condition of a mole channel after one year is seen. Evidence of roof collapse can be easily observed.

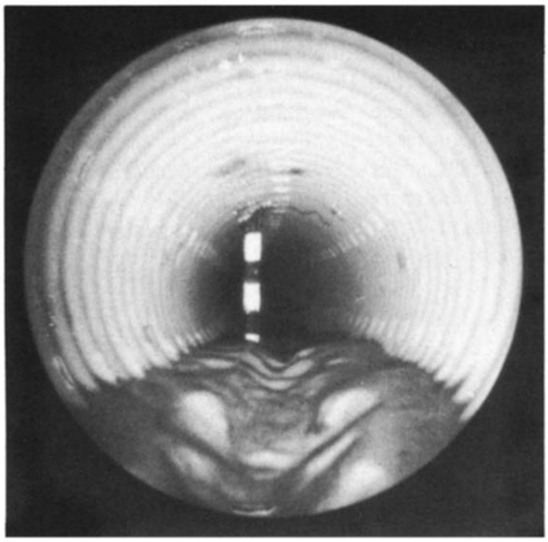

Fig. 5. Silt deposit in an 80 mm diameter corrugated plastic drain tube

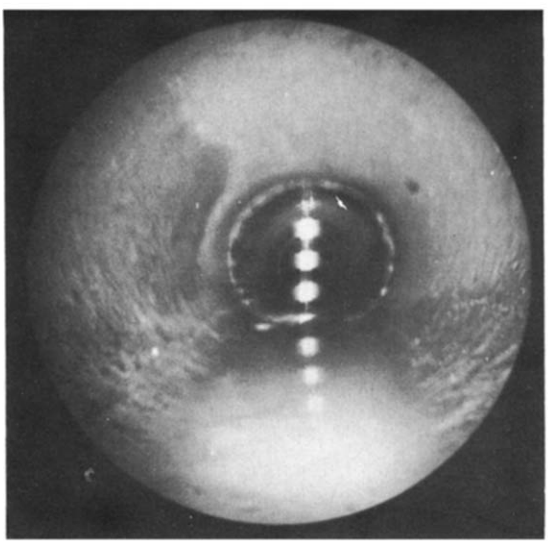

Fig. 6. Water flowing in a 100 mm diameter clay tile drain

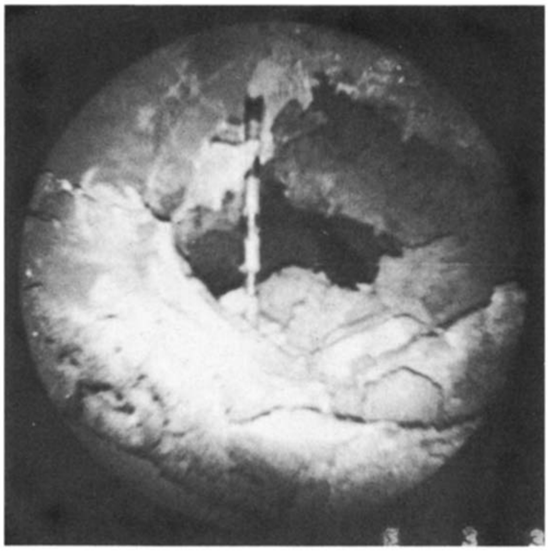

Fig. 7. Roof collapse in a mole drain

5. Practical considerations

To enable regular observations of drains to be made the access tubes must be placed in such a way as to integrate with the farming operations on site. In arable land the tubes may be left protruding above the soil surface and sealed with a rubber bung. Placement of the tubes linked to a tramline system has allowed harvesting, cultivations, reseeding and spraying operations to be carried out with little or no damage to the tubes. In grassland, or when installed in arable land before primary cultivations, the tubes may be cut off below ground level after normal installation and sealed with a rubber bung. An alternative solution is to use shorter tubes with sockets to accept extensions to the surface later. A metal plate placed over the buried tube allows the tubes to be relocated easily using a metal detector, however mapping the site and the location of the tubes is also recommended.

Taking photographs is very time-consuming, the installation and setting up of the tripod takes considerably longer than the simple insertion of the borescope into the access tube. It has been found that a written and sketched record of the condition and dimensions of the drains is in many cases satisfactory.

6. Conclusions

The borescope has proved to be a useful instrument for non-destructively monitoring drainage systems. The equipment is portable and although based on conventional optics has been successfully used in intensive studies of drain tube performance in both the United Kingdom in winter and the Nile Delta in mid-summer. The instrument has also been used to study root growth around glass tubes inserted into the soil. As a result of the use of this instrument detailed information on the performance of drain tubes has been gained.

Acknowledgements

The authors are grateful for the support of the Agricultural Research Council and the Ministry of Agriculture, Fisheries and Food who provided the funds for the purchase of the equipment described here. The authors are especially grateful to Mr R. Ford and Mr N. Warner for their helpful comments.

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