## Monitoring and Maintenance of Horizontal Drains

---- This Practice Note encloses a guidance note (Appendix A) on the monitoring and maintenance of horizontal drains installed in connection with any building works. It amplifies the relevant parts of Chapters 4 and 11 of the Geotechnical Manual for Slopes (Second Edition).

### Drainage Works in Scheduled Area No. 1

2. Maintenance of horizontal drains installed in the Mid-levels area (specified as Scheduled Area No. 1 in the Fifth Schedule of the Buildings Ordinance) is subject to additional control under Buildings Ordinance section 28A to 28D.

### Other Drainage Works

3. In areas outside the Scheduled Area No. 1, the use of horizontal drains which require specific long-term maintenance in situations where there is a significant risk to life will only be approved where a positive undertaking is received that the necessary maintenance will be carried out to ensure their continued effectiveness.

4. Since private developments are normally subject to change of ownership, it is envisaged that an acceptable undertaking could only be given in rare cases such as where a major private body undertakes a development for its own specific purposes and it can be accepted that the ownership will not change.

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# Guidance Note on Monitoring and Maintenance of Horizontal Drains

## Introduction

1. Horizontal drains are installed in both rock and soil slopes in Hong Kong. The drains installed in rock slopes are typically short and are used mainly to drain individual rock joints or local areas of groundwater seepage. Longer drains tend to be installed in soil and mixed rock/soil slopes, usually with the aim of achieving an overall reduction in groundwater pressures within the slope. This guidance note is mainly concerned with the latter type of drains.

2. A horizontal drain system can be an effective slope stabilization measure provided that due care is given to design requirements and construction methods. Even where such care has been exercised, it is important to ensure that the system will perform satisfactorily in the long term by carrying out appropriate monitoring and maintenance schemes. The cost of monitoring and a commitment to long-term maintenance should be considered at the preliminary design stage in comparison with other stabilization measures before deciding whether to adopt a horizontal drain system.

3. The procedures described here are intended to cover horizontal drain systems that are designed to lower groundwater pressures so that the required factor of safety of a slope can be achieved (Geotechnical Manual for Slopes, Second Edition. Tables 5.1 & 5.4). These procedures need not be followed for other drain systems, but regular inspection and maintenance should still be carried out.

4. To ensure satisfactory performance of a horizontal drain system, the designer of the system should be closely involved with the monitoring and should prepare a suitable programme of maintenance. The maintenance authority should appoint a suitably-experienced maintenance officer to be responsible for compiling the maintenance inspection records. If the maintenance authority has any reason to believe that the system is not performing effectively, this should be brought to the attention of the designer without delay. This approach is consistent with the more general guidance on slope maintenance given in Chapter 11 of the Geotechnical Manual for Slopes

## Monitoring Requirements

5. As part of the initial design stage, the designer should devise an instrumentation scheme which is suitable for the project, including the type, number and location of piezometers for groundwater monitoring and the techniques to be used for drain flow measurement. Allowance should be made for the maintenance and replacement of defective instruments within the contract and for any subsequent period when instrument monitoring is likely to be required. The piezometers should be installed at an early stage. preferably at the same time as the ground investigation for the design of the horizontal drain system is carried out. Open hydraulic piezometers are commonly used for long-term observation (GEOGUIDE 2 : Guide to Site Investigation, Section 20.2.3). `Halcrow buckets' are often installed in the piezometer tubing to detect the highest piezometric level that has occurred in the period since the last reading. For a large drain installation, the water from individual drains may he conducted to a single point through a system of pipes and channels to facilitate drain flow measurement.

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6. The monitoring of piezometric levels and drain flow rates should be carried out at least once every two months during the dry season and weekly during the wet season. The latter should be carried out within two days of any heavy rainstorm (for example, rainfall $>100$ mm in 24 hours). All drains and piezometers on the site should monitored. The need for frequent site visits and manual monitoring can be avoided by using computerized automatic recording systems, but before adopting such a system the designer should consider carefully his requirements in relation to the cost and necessary support services.

7. The monitoring of piezometric levels should start at the earliest stage and should preferably cover two wet seasons before the design is finalized. If this is not possible, then the results from continuing monitoring during the period of design and preparation of tender documents should be used to make a final review of the design. The data should be used to establish the `base groundwater levels' in the wet and dry seasons prior to drain installation. The monitoring of both piezometric levels and drain (low rates should be carried out both during and after the installation of the system. Monitoring should be terminated in accordance with the procedures described in paragraph 13. The data obtained during construction may be used in an `observational approach' to design, whereby the design parameters, such as the spacing of the drains, are modified during construction in accordance with the monitoring results. This approach is particularly helpful for horizontal drain installation because the performance of individual drains is sensitive to the heterogeneous nature of the ground conditions commonly encountered in Hong Kong.

8. Particular attention should be given in monitoring programmes to cases where the existing groundwater regime may be modified significantly by adjacent development or pumping works.

**Evaluation of Drain Performance**

9. The effectiveness of a horizontal drain system should be gauged by considering, in descending order of significance, the following aspects of overall groundwater response at the site:

(a) the piezometric levels after drain installation should not rise above the design level in heavy rainstorms,

(b) the `base groundwater level' after drain installation should be lower than the pre-installation value,

(c) the range of groundwater fluctuations (storm response) should be lower than the pre-installation values, and

(d) the rate of drop of piezometric level after a rainstorm should be faster than the pre-installation rate, with the level returning to normal within & few days after the rainstorm.

10. In addition to the above, drain flow rates due to similar rainfalls measured shortly after installation and subsequently after a long period of tine should also provide an indication of the long-term performance of the drains.

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11. Other factors which the designer should consider in the evaluation of drain performance include the adequacy of the acquired data, reliability of the design data (including the assumed groundwater conditions), the number of heavy rainstorms during the monitoring period, and the degree of contribution of the drains to the calculated factor of safety.

**Termination of Monitoring**

12. The designer should plan groundwater monitoring with the object of assessing the effectiveness of a horizontal drain system before the end of the Contract Maintenance period. However, monitoring should be continued beyond this period if the designer considers it necessary on the basis of the criteria given above. Once the effectiveness of the system has been fully assessed, the designer should then decide either to terminate the monitoring if he is satisfied with the performance, or to recommend remedial measures if he considers that the system is not performing effectively. If remedial works are to be carried out, monitoring of piezometers and drain flows should continue in order to gauge the effectiveness of the improved new system. Further remedial works may be necessary. This process should be continued until the designer is satisfied that the system is performing effectively.

13. Subsequently, if there is observational evidence of possible substantial changes in existing groundwater conditions (for example, large variation in drain flows, signs of new surface seepage), this should be brought to the attention of the designer by the maintenance authority. The designer can then assess whether the monitoring should be reactivated.

**Maintenance Requirements**

14. Regular maintenance of horizontal drains is required to ensure that they function properly and do not become clogged. Materials likely to close drains are organic elements (plant roots, fungi or algae), fines washed out of the surrounding soils, and precipitates of calcium, magnesium, iron and other compounds. In most cases, flushing with a clean water jet under controlled pressure should be adequate to restore the drain function. If soil deposits have dried up in the drain, then it is necessary to brush the drain during the flushing. Cleaning of the drain should commence from the deep end and proceed toward its outlet. This process should be repeated until the water flowing out of the drain appears clean.

15. The programme of maintenance and the `as built' details of the drain system should he prepared by the designer and handed over to the maintenance authority. Maintenance of the drains should be carried out at least once during the Contract Maintenance period and then once annually. The maintenance work should include inspection of the drains and surroundings, removal of weeds, clearing of outlets and flushing the drains with a water jet (as described above). In addition, if the drains contain removable inner liners, these should be replaced where considered necessary on the basis of the site inspection, the flushing operations and previous observations (for example, where the drains are found to be blocked or where drain flows are substantially reduced). All the drains at the site should be examined and maintained. A record of the observations made in the maintenance inspections and details of the work done should be kept tor future reference in the maintenance inspection record. A note should also be made in the maintenance

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inspection record if any significant changes in drain flows or new areas of surface seepage are observed (see paragraph 14). If large increases in flow are recorded the discharge should be tested and the surrounding area inspected to assess whether the water originates from leaking services. If this appears to be the case, the appropriate authority should be notified and requested to trace and repair the leak.

16. In some special cases (for example, an extensive drain system in a natural hillslope where access to the outlet locations is difficult), a more cost-effective maintenance plan may consist of monitoring the effectiveness of the system using permanently-installed piezometers, and carrying out the cleaning and flushing of drains only if shown to be necessary by the monitoring. Routine inspections and clearing of the drain outlets should still be carried out regularly.

17. In all cases, it is necessary for a suitably-experienced maintenance officer to examine the system when the annual maintenance is being carried out. This will enable problems to be identified and corrected at an early stage.

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