Information Note 05/2022 **November 2022**

Landslip Prevention and Mitigation Works at Po Shan, Mid-levels

Key Message: The Geotechnical Engineering Office completed the landslip prevention and mitigation works at Po Shan, Mid-levels in December 2009. An innovative regional groundwater regulation system comprising a pair of drainage tunnels with a network of 172 sub-vertical drains has been implemented to control the regional groundwater levels so as to reduce the risk of major landslides and enhance public safety.

Introduction

The Mid-levels area in the vicinity of the Po Shan hillside is underlain by thick bouldery colluvium, which is old landslide debris deposited some 50 000 years ago. This colluvium is susceptible to development of high groundwater levels and to failure when disturbed, e.g. by construction activities. The Po Shan area was affected by significant historical landslides.

Past Studies and Works

A regional stability study of the Mid-levels area completed in 1982 revealed that the Po Shan hillside was affected by high groundwater levels and was of marginal stability. The Study recommended that groundwater drainage works be carried out to lower the groundwater table.

In 1984-85, 73 horizontal drains (up to 90 m long each) were installed in the area to lower the groundwater table in order to improve the stability of the hillside against large-scale slope failure. The drains have served the intended purposes in drawing down the groundwater table and no large-scale instability occurred on the hillside since installation of the drains.

Monitoring data in the early 2000s showed that the groundwater levels could be rather high locally during periods of heavy rainfall and that some of the horizontal drains, which were more than 20 years old, exhibited a decreasing trend of outflow in recent years. With improved knowledge of natural terrain landslide hazards, it is recognised that the hillside is susceptible to shallow landslides that may result in mobile debris flows. In the event of such failures, the existing horizontal drains could be ruptured.

Innovative and Sustainable Groundwater Regulation System

Reprovision of a more robust groundwater drainage system was considered in 2005, taking into account the following factors in the engineering design:

(i) The function of the existing horizontal drains should be maintained during the construction period.

(ii) The new system should not be affected by shallow landslides.

(iii) The new system should have reliable long-term performance.

(iv) The Po Shan hillside falls within the Pokfulam Country Park grown with many

plants having conservation value.

(v) There was limited works space.

(vi) The adjacent old buildings are sensitive to settlement associated with excessive groundwater drawdown.

(vii) Earthworks should be minimised due to regional stability and environmental concerns.

After holistic evaluation of various options, a groundbreaking and sustainable scheme of an underground tunnel system with sub-vertical drains to effectively regulate the regional groundwater regime was adopted. This novel engineering solution was a pioneer in Hong Kong. The project was awarded the Second Runner-up in the construction category of Innovation Award for the Engineering Industry 2012/13.

Works Contract

The landslip prevention and mitigation works contract commenced in mid-2006 and was successfully completed in December 2009 at a total cost of about HK$165 million. The contract included the following major works items:

(i) Slope reinforcement works of the portal area (totally 285 nos. of soil nails).

(ii) Flexible landslide barriers for mitigating shallow landslide risk (five metres high and 3 000 kJ capacity, totally 120 m in length).

(iii) Drainage tunnels (3.5 m diameter, total length of 500 m for two tunnels at max. 100 m below ground level).

(iv) Sub-vertical drains (totally 172 nos., each varies from 24 to 100 m in length).

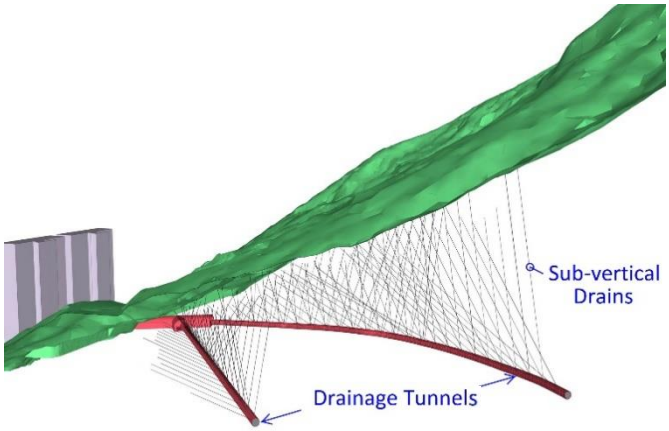
(v) Natural hillside stabilisation works (totally 685 nos. of soil nails).

(vi) Boulders stabilisation works with rock dowels and buttresses.

Innovative Technologies Adopted

The project introduced many novel features and technological advances, including:

(i) use of the technique of Horizontal Directional Coring as a ground investigation tool to obtain continuous rock core samples along curved alignments;



(ii) deploying a retractable Tunnel Boring Machine for excavation of the two drainage tunnels;

(iii) drilling and installation of sub-vertical drains of maximum length exceeding 100 m within the small and congested tunnel space;

(iv) establishing an automatic real-time groundwater monitoring system; and

(v) adopting an automated pressure relief system to control the groundwater levels within a pre-defined range.

In addition, one of the drainage tunnels is also used to house a seismograph station of Hong Kong Observatory to monitor earthquakes worldwide.

Po Shan Drainage Tunnel - Landslide Sci-Tech Chamber

Given the uniqueness of the Po Shan Drainage Tunnel and its novel features, the GEO established a "Landslide Sci-Tech Chamber" in the tunnel in 2021 to convey the importance of slope safety to the public. In the Chamber, there are four galleries covering different themes, which include:

(i) Po Shan Memorial Gallery – presents precious historical photos and records about the landslide incident in Po Shan Road to commemorate the pain and reflect the lesson learnt of the disaster;

(ii) Climate Change Impression Gallery – raises public awareness of the landslide risk in Hong Kong and the importance of sustained effort to ensure slope safety under extreme weather;

(iii) Landslide Wisdom Gallery – exhibits the landslide history of Hong Kong over the past hundred years and the evolvement of the Hong Kong Slope Safety System; and

(iv) Drainage Tunnel Expression Gallery – visualizes the innovations of the groundwater regulation system through Augmented Reality (AR) application and demo operation of the sub-vertical drains.

The Po Shan Drainage Tunnel - Landslide Sci-Tech Chamber is open to public individuals, schools or organisations for application of guided visits. Public members can apply for a visit via the website of Po Shan Drainage Tunnel - Landslide Sci-Tech Chamber (https://hkss.cedd.gov.hk/PoShanTunnel/eng/).

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