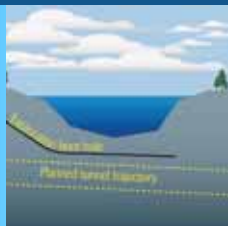


# Joint Technical Seminar by AGS(HK), HKIE and HKTS GI for Tunnel Projects – Horizontal Directional Coring



Presented by Janice Tam

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GI for Tunnel Projects – HDC

## Ground Investigation (GI) for Tunnel Projects - Horizontal Directional Coring

### Content

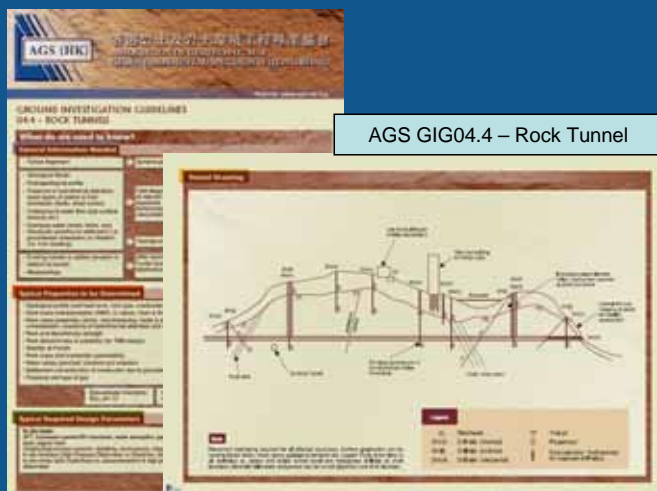
1. GI Planning for Tunnel Projects
2. Advanced Drilling Method – Horizontal Directional Coring
3. Project References
4. Summary

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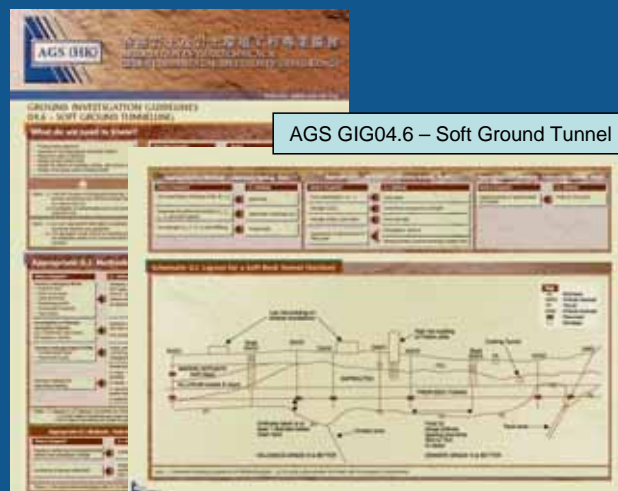
# 1. GI Planning for Tunnel Projects

## Guidelines for GI Planning

1. AGS-HK (2003), "Ground Investigation Guidelines"
2. GEO Geoguide 2 (1987), "Guide to Site Investigation"
3. GEO Geoguide 4 (1992), "Guide to Cavern Engineering"
4. GEO TGN24 (2005), "Site Investigation for Tunnel Works"



AGS GIG04.4 – Rock Tunnel

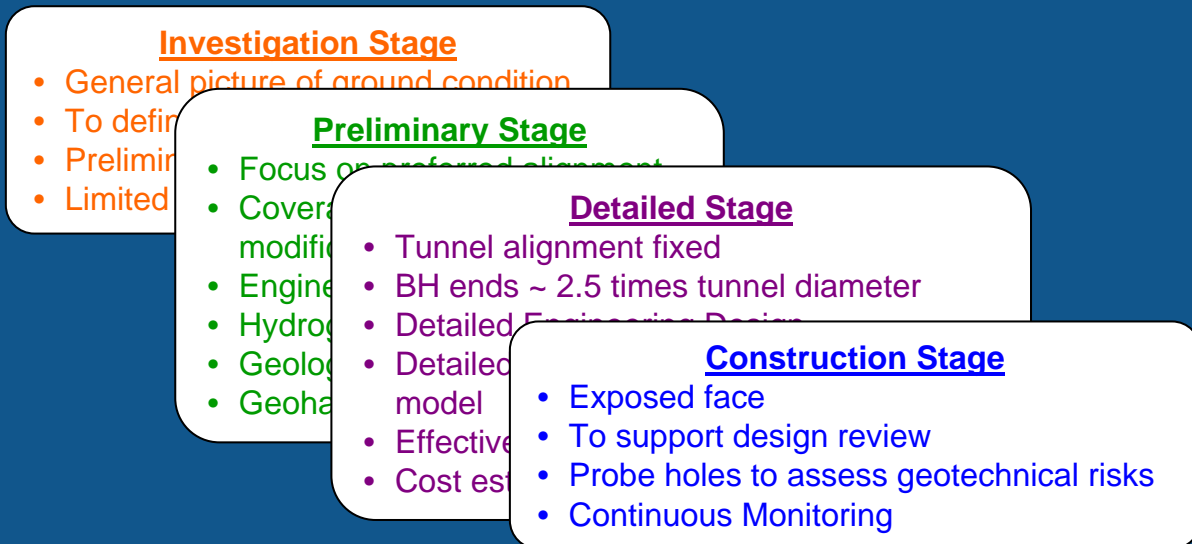


AGS GIG04.6 – Soft Ground Tunnel

# 1. GI Planning for Tunnel Projects

## GI Strategies should be phased (TGN24, 2005)

1. Different stages of the project have different requirements.
2. Alignment and design requirements can change during project planning or design.



## 1. GI Planning for Tunnel Projects

A comprehensive GI plan is essential to identify

1. Potentially problematic ground
2. Groundwater conditions
3. For Tunnel Projects, it is valuable to obtain continuous geological and engineering information along tunnel alignment.

### Advantages of using HDC

1. Continuous core sample.
2. Extent of problematic rock condition.
3. Genuine groundwater inflow measurement.
4. Reduce construction risks.
5. Facilitate the project programme in terms of time and cost.

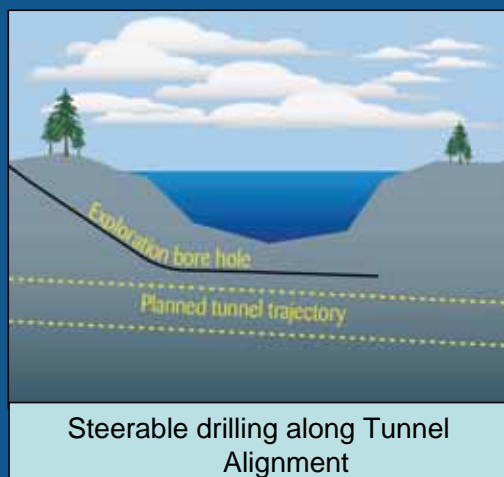


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## 2. Technically Advanced Drilling Method – HDC

### Background of the HDC Technology

1. The system for directional coring was developed in Norway over 20 years ago.
2. A wireline version was subsequently launched in 2001.
3. The key specialist service provider, a Norwegian registered company, has more than 20 years of worldwide experience in directional coring.



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## 2. Technically Advanced Drilling Method – HDC

The HDC system comprises **3** main components

1. Steerable drilling – using steerable directional core barrel.
2. Borehole surveying – using a miniature electronic multishot (EMS).
3. Windows software package for the planning and plotting of the borehole trajectory.



Steerable Drilling Barrel



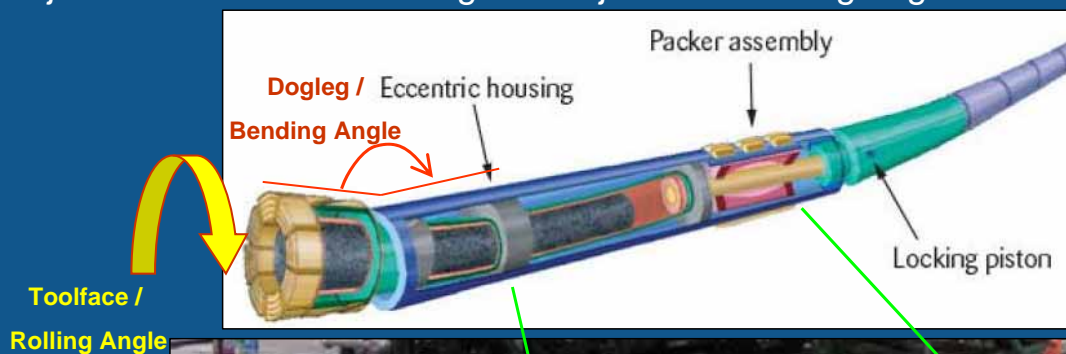
Borehole surveying tool

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## 2. Technically Advanced Drilling Method – HDC

The **3** main components of a steerable barrel

1. Locking Piston – to provide a locked position for the barrel.
2. Packer Assembly – to maintain the toolface position during the drilling process.
3. Adjustable Eccentric Housing – to adjust the bending angle.

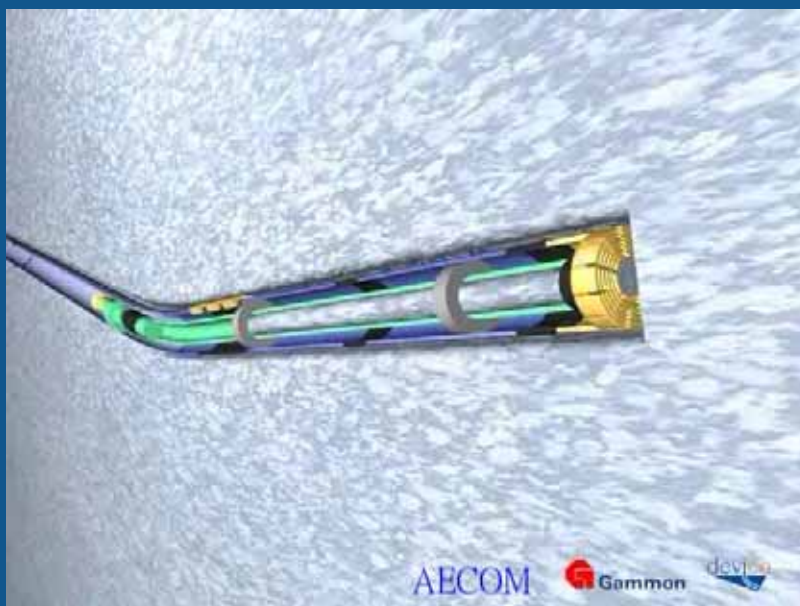


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## 2. Technically Advanced Drilling Method – HDC

### Working Principles

1. Define the trajectory and tolerance
2. Straight section - Conventional Wireline Drilling
3. Curve section - Steerable Drilling System
4. Navigation by toolface & dogleg angle
5. Borehole surveying (i.e. to get the azimuth and inclination)



### Steering System:

1. Non-rotating outer barrel: Slides in a set toolface while drilling
2. Rotating inner corebarrel: Drive the bit
3. Non-rotating innertube: Collect the core

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## 2. Technically Advanced Drilling Method – HDC



### Steerable Barrel

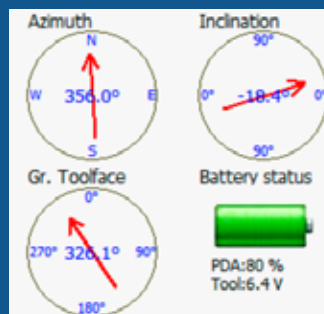
1. Provide deviated rock core when drilling in a controlled direction at a control rate.
2. Maximum core-run: 3 m.
3. Core diameter: 31.5 mm in deviated section.
4. Hole diameter: B-size (60 mm) or N-size (76 mm) in straight section.
5. Maximum bending angle: 20 deg/30 m.
6. Optimum bending angle: 9 deg/30 m (R=180 m)

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## 2. Technically Advanced Drilling Method – HDC

### Borehole Surveying Tool – PeeWee EMS

1. A miniature electronic multishot that is used for surveying of borehole profile.
2. Length of 0.975 m.
3. Diameter of 30 mm.
4. To provide orientation of a borehole

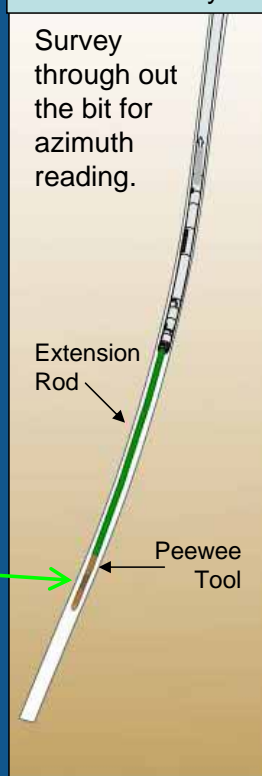


#### Drillhole Survey

Survey through out the bit for azimuth reading.

Extension Rod

PeeWee Tool



## 2. Technically Advanced Drilling Method – HDC

### Coring Dimensions

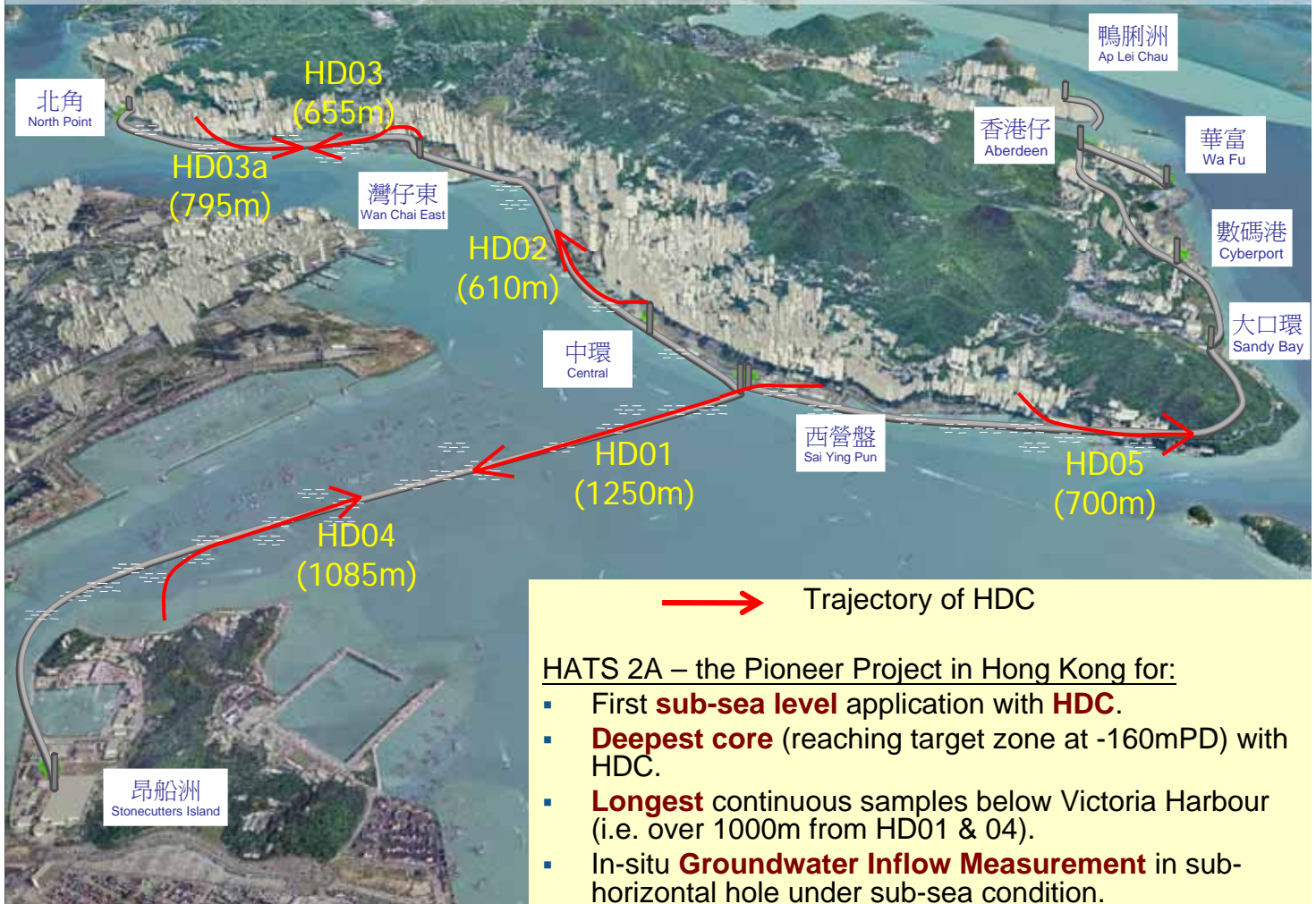
Type of Barrel	Hole Diameter	Core Diameter	Length of Core Run	Typical Production Rate
DV (in curve section)	76 mm	31.5 mm	3 m	9 m/day
NQ (in straight section)	76 mm	47 mm	3 or 6 m	25 m/day

DV

NQ



### 3. Project References – HATS 2A



### 3. Project References – HATS 2A

#### Site Setup of HDC



HDC04 at Stonecutters Island (1085 m)



HDC02 at Central (610 m)

Working Area (length x width)	Length/Depth of Corehole
25 m x 20 m	~ 1000 m
15 m x 10 m	~ 500 m

### 3. Project References – HATS 2A

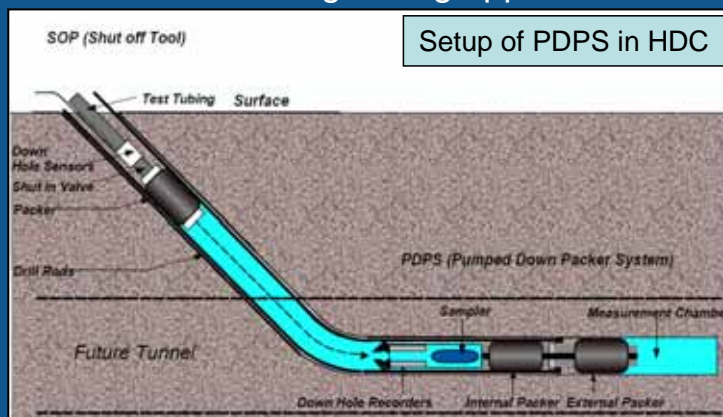
#### Duration of Works

HDC	Duration	Length	Level of Horizontal section	Nos. of Inflow Test	Nos. of Packer Test	Nos. of IP Test
HD01	10 months	1250 m	~140 mPD	10	13	20
HD02	5 months	610 m	~145 mPD	4	4	4
HD03	6 months	655 m	~145 mPD	6	12	12
HD03a	5 months	795 m	~150 mPD	5	10	0
HD04	8 months	1085 m	~135 mPD	0	8	24
HD05	5 months	700 m	~135 mPD	5	9	4

### 3. Project References – HATS 2A

#### Field Tests – Water Inflow Tests using Pump Down Packer System (PDPS)

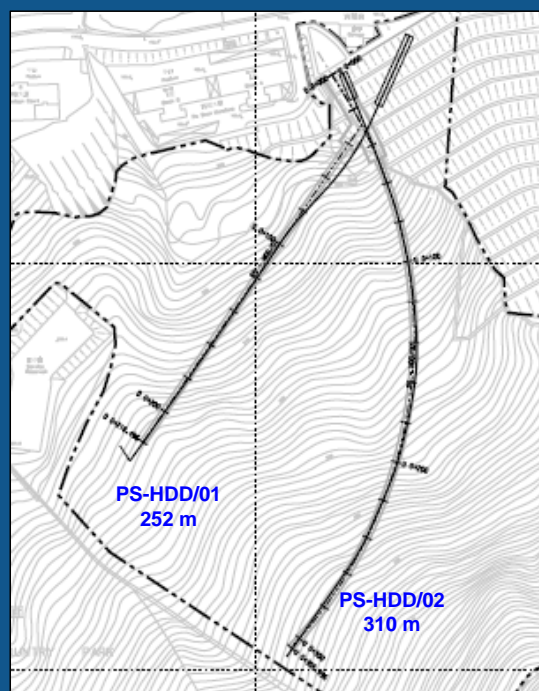
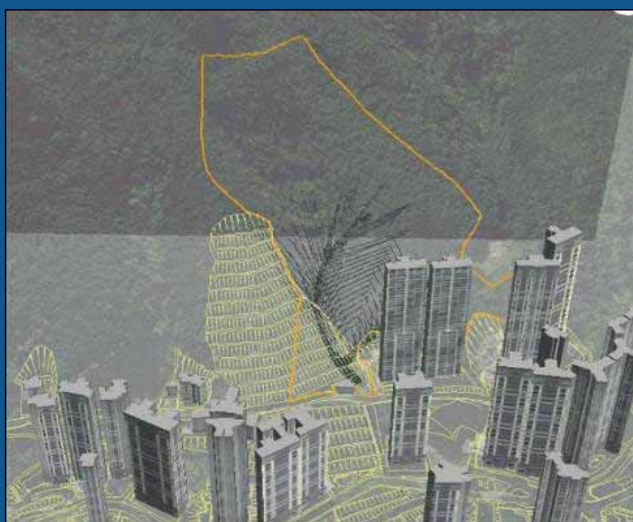
1. Sectional inflows in HDC, along the proposed tunnel alignment.
2. Water quantity seeping naturally from the formation as a result of pressure difference (i.e. predicting inflow during excavation)
3. A more realistic hydrogeological model than using the conventional water absorption test.
4. To determine an effective grouting approach.



### 3. Project References – Po Shan Road

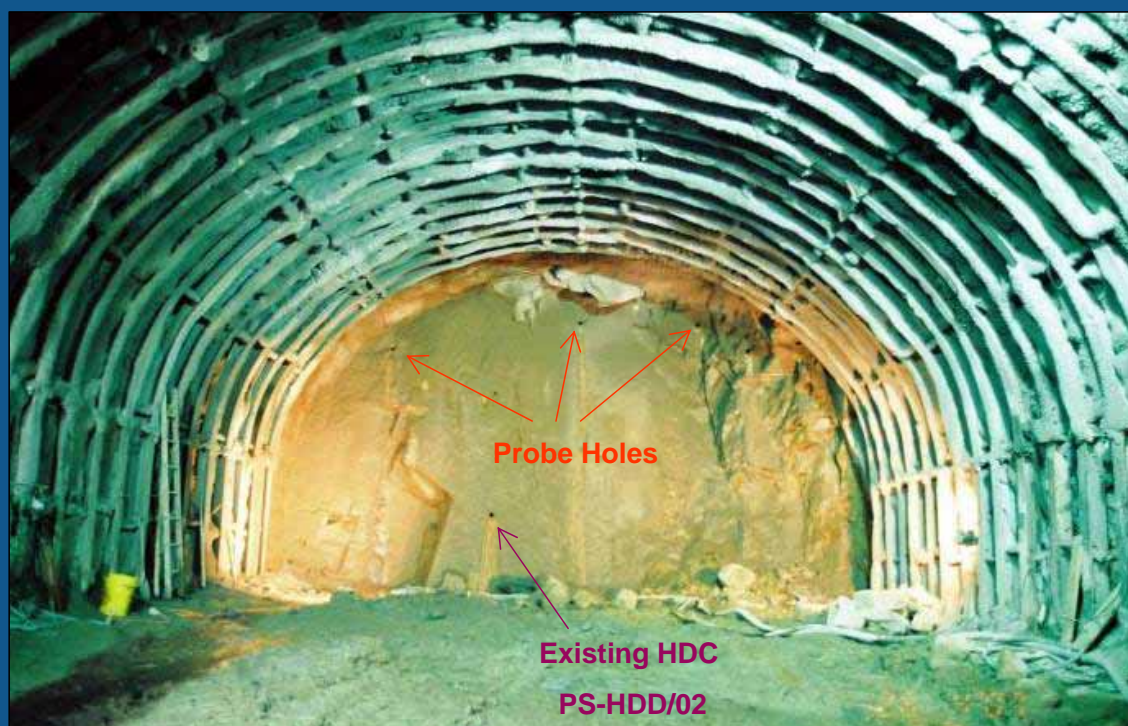
#### Drainage Tunnel Design & Construction

1. 2 nos. of HDC
2. Nov. 05 to Jan. 06
3. Tolerance envelope of 2 m radius



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### 3. Project References – Po Shan Road



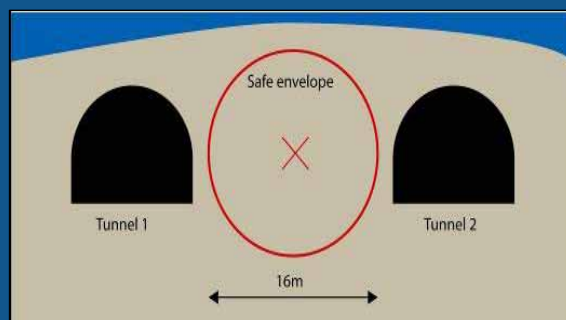
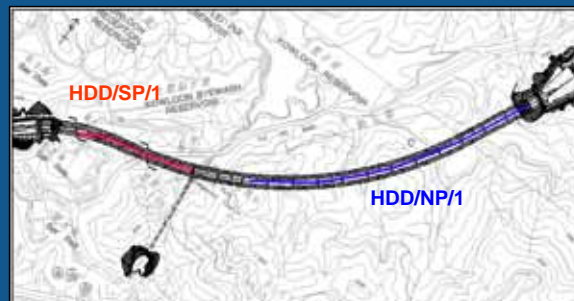
Tunnel excavation at to Chainage 26.0  
Probe holes drilled at clock positions 10, 12 and 2.

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### 3. Project References – Route 8 – Eagle’s Nest Tunnel

#### Road Tunnel at Construction Stage

1. HDD/NP/1 (1152 m), March 04 to Sept. 04
2. HDD/SP/1 (550 m), Dec. 04 to Jan. 04
3. Tolerance envelope of 8 m radius



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### 4. Summary

#### An Appropriate Design of GI Programme

1. Reliable information along tunnel.
2. Minimize uncertainties in ground models.



#### Interpretations of GI Data for Design and Risk Management

1. Defining a safe and economical construction design.
2. Reducing the Geological Risks.
3. Reducing the Contractual Risks.

In order to achieve an Effective GI Programme,  
a clear understanding of the project objectives is required.  
Make good use of the available Guidelines before Planning.

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THANK YOU.

