

# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 善用岩洞的需要 Need for Enhanced Use of Rock Caverns

香港有很多陡峭的山坡，限制了市區的擴展。土地是香港珍貴的資源，發展岩洞是土地供應的可行來源。有見及此，政府現正進行「岩洞發展長遠策略」研究，以制定合適措施，令岩洞成為開拓土地資源的一項可持續方法。

Hong Kong's steep hilly terrain limits the growth of the urban areas. Land is a scarce resource in Hong Kong. Developing rock caverns is a viable source of land supply. Therefore, the Government is conducting a study on "Long-term Strategy for Cavern Development" with a view to developing suitable measures to render it as a sustainable means of expanding land resources.



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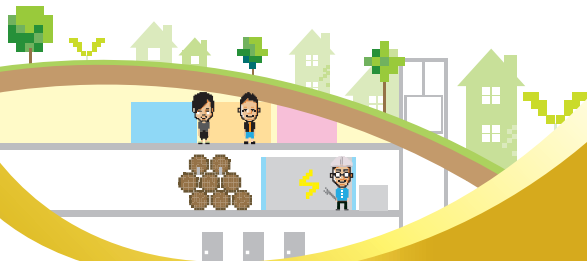
### 小知識Tips

岩洞是甚麼？  
What are rock caverns?



岩洞是指在岩體內以人工開挖的大型空間，可作許多有利民生的土地用途。

Rock caverns refer to large man-made spaces in rock, which offer many beneficial applications in terms of land uses.



# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 香港現行的岩洞發展 Existing Cavern Development in Hong Kong

自八十年代起，為配合社會需要，香港有多項公共設施在岩洞內建成，包括太古及西灣河港鐵站大堂、港島西廢物轉運站、赤柱污水處理廠和狗虱灣爆炸品倉庫。於二〇〇九年，香港大學利用岩洞重新安置西區海水配水庫，以騰出地面土地發展百周年校園。

Since the 1980s, a number of public facilities in Hong Kong have been built in caverns to meet the needs of the community, namely the Tai Koo and Sai Wan Ho MTR station concourses, Island West Transfer Station, Stanley Sewage Treatment Works and Kau Shat Wan Explosives Depot. In 2009, the University of Hong Kong constructed caverns to re-house the Western Salt Water Service Reservoirs underground to release land for the Centennial Campus development.



# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 香港岩洞發展的適合性 Suitability of Cavern Development in Hong Kong

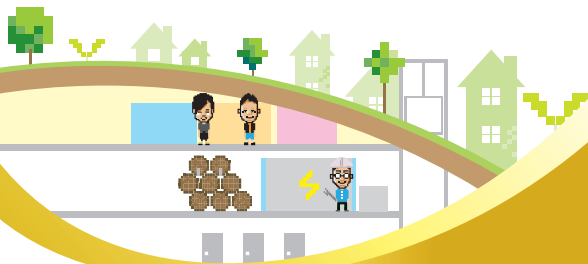


香港地勢多山，岩石堅固，非常適合發展岩洞。於二〇一一年三月完成的「善用香港地下空間」可行性研究中，土木工程處綜合了一系列空間數據，繪製出一幅全港岩洞發展適合性地圖。該地圖顯示約三份之二的香港土地適合發展岩洞。

保守推算，若能利用當中百份之五的土地發展岩洞，可提供平面面積約三千五百公頃的空間作發展用途(相等於一百八十個維多利亞公園的面積)。如善用三維概念進行岩洞設計，可使用的地下空間總面積將會更大。

The hilly terrain and underlying geology of Hong Kong offer an excellent opportunity for rock cavern development. In the feasibility study on "Enhanced Use of Underground Space in Hong Kong" completed in March 2011, the Geotechnical Engineering Office produced a map that classified the suitability of developing rock caverns throughout the territory based on sets of spatial data. The map shows that about two-thirds of the land area of Hong Kong is suitable for cavern development.

Conservatively assuming that 5% of this area could be made available for cavern development, this could provide some 3,500 ha of developable land in plan area (equivalent to about 180 nos. of Victoria Park). If we think three-dimensionally in cavern design, a substantially greater usable area could be created in underground space.



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土木工程拓展署  
Civil Engineering and  
Development Department

## 善用岩洞帶來的好處 Reaping the Benefits




**創造空間**  
Creating space  
例子: 香港大學百週年校園  
e.g. HKU Centennial Campus



**遷移不合適的土地用途**  
Removing incompatible land uses  
例子: 港島西廢物轉運站  
e.g. Island West Transfer Station



**保護環境**  
Protection of environment  
例子: 赤柱污水處理廠  
e.g. Stanley Sewage Treatment Works



**穩定和安全環境**  
Stable and secure conditions  
例子: 數據中心  
e.g. Data centre



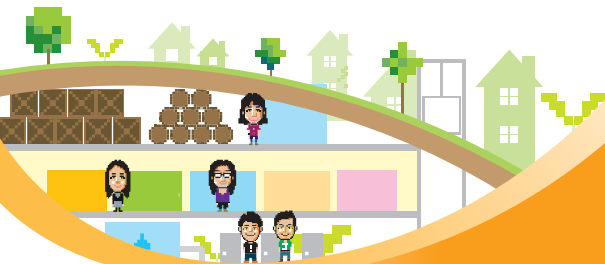
**靈活設計**  
Flexibility for layout and geometry  
例子: 貯物庫、物流中心  
e.g. Warehousing, logistics, etc.



**靈活擴展**  
Flexibility for future expansion  
例子: 挪威國家檔案館  
e.g. National Archives, Norway



**提供石材來源**  
Providing source of rock products  
例子: 混凝土骨料  
e.g. Concrete Aggregate



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土木工程拓展署  
Civil Engineering and  
Development Department

## 地下空間可以有什麼用途？ What are the Opportunities Underground?

只限厭惡性設施  
Restricted to "NIMBY" Facilities only ?



垃圾轉運站  
Refuse Transfer Station

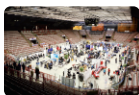


污水處理廠  
Sewage Treatment Works



爆炸品貯存庫  
Explosives Magazine/Depot

還有其他可能性  
Other Possibilities



挪威-Gjevik奧林匹克運動館  
Gjevik Olympic Mountain Hall, Norway



芬蘭-Itäkeskus游泳館  
Itäkeskus Swimming Hall, Finland



美國-酒窖  
Wine Storage, USA



芬蘭-停車場  
Vehicle Parking, Finland



(ATLAS Experiment © 2013 CERN)  
歐洲-地下研究實驗室  
Underground Research Laboratory, Europe

### 世界各地的地下設施 Examples of Underground Facilities in Different Countries



挪威-國家檔案館  
National Archives, Norway



瑞典-數據中心  
Data Centre, Sweden



法國-食品貯存庫  
Food Storage, France



墨西哥-餐廳  
Restaurant, Mexico



# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 岩洞發展路線圖 Roadmap for Rock Cavern Development



深井污水處理廠  
Sham Tseng Sewage  
Treatment Works



西貢污水處理廠  
Sai Kung Sewage  
Treatment Works



鑽石山食水及海水配水庫  
Diamond Hill Fresh Water and  
Salt Water Service Reservoirs

### 其他三個項目 3 Additional Projects

### 岩洞發展長遠策略 Study on Long-term Strategy for Cavern Development

- 擬備全港岩洞總綱圖  
Prepare a territory-wide cavern master plan
- 制定推動岩洞發展的政策指引  
Formulate policy guidelines to facilitate cavern development
- 為合適政府設施訂立一套有系統遷移至岩洞的計劃  
Develop a systematic relocation programme for suitable Government facilities

### 首個計劃-沙田污水處理廠 1st Scheme - Sha Tin Sewage Treatment Works



沙田污水處理廠  
Sha Tin Sewage Treatment Works

- 「善用香港地下空間」  
可行性研究於2011年3月完成  
Feasibility Study on 'Enhanced Use  
of Underground Space in Hong  
Kong' completed in March 2011





# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 岩洞發展長遠策略研究 - 工作重點 Study on Long-term Strategy for Cavern Development - Key Tasks

### 1 岩洞總綱圖 Cavern Master Plan

編製全港性岩洞總綱圖，預留策略性區域供岩洞發展。

Prepare a territory-wide Cavern Master Plan for reserving strategic areas for cavern development.

### 2 系統性搬遷計劃 Systematic Relocation Programme

物色適合遷往岩洞的政府設施，並為此訂立一套有系統的搬遷計劃，從而逐步釋放地面土地作其他有效益的用途。

Identify suitable government facilities for relocation to caverns and develop a systematic relocation programme, thereby gradually releasing the surface land for other beneficial uses.



### 適合遷往岩洞的政府設施的例子 Examples of Government facilities suitable for relocation to caverns





# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 岩洞發展長遠策略研究 - 工作重點

### Study on Long-term Strategy for Cavern Development - Key Tasks

#### 3 政策指引 Policy Guidelines

制定相關的政策指引，令公營項目在規劃階段已把使用岩洞納入考慮方案內。此外，亦會探討合適機制，促進私營界別參與岩洞發展。

Formulate policy guidelines so that cavern options would be considered in the initial planning stage of government projects and explore suitable mechanisms to facilitate private sector participation in cavern development.

#### 4 技術指引 Technical Guidelines

制定或更新相關的技術指引，以推動岩洞發展。

Prepare or update relevant technical guidelines to enhance cavern development.





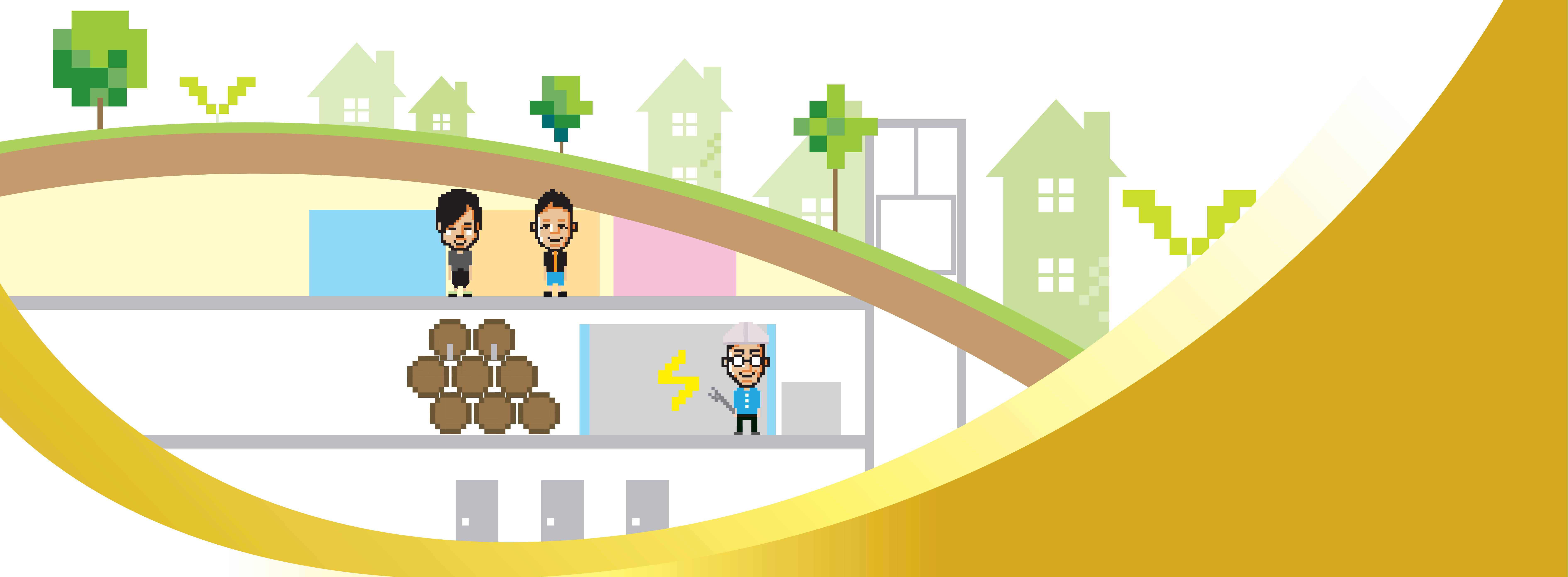
# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 岩洞發展長遠策略研究 - 工作重點 Study on Long-term Strategy for Cavern Development - Key Tasks

### 5 概念性方案 Conceptual Schemes

評估在岩洞興建不同類型設施的可行性，並物色合適地點發展概念性方案。

The Study will evaluate the engineering feasibility of housing various facilities in caverns and identify suitable locations for development of conceptual schemes.





# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 其他正在推行的岩洞發展項目 Other Ongoing Cavern Development Projects



### 搬遷沙田污水處理廠往岩洞 Relocation of Sha Tin Sewage Treatment Works to Caverns



渠務署已大致完成項目的可行性研究，並計劃在2014年下半年為搬遷工程展開勘測和設計工作。

Drainage Services Department has substantially completed the Feasibility Study and will commence the Investigation and Design for the relocation proposal in the second half of 2014.



### 搬遷深井污水處理廠往岩洞 Relocation of Sham Tseng Sewage Treatment Works to Caverns



渠務署計劃在2014年下半年展開項目的可行性研究，預計需時2年。

Drainage Services Department will commence the Feasibility Study in the second half of 2014. The study will take 2 years to complete.



### 搬遷西貢污水處理廠往岩洞 Relocation of Sai Kung Sewage Treatment Works to Caverns



渠務署計劃在2014年下半年展開項目的可行性研究，預計需時2年。

Drainage Services Department will commence the Feasibility Study in the second half of 2014. The study will take 2 years to complete.



### 搬遷鑽石山食水及海水配水庫往岩洞 Relocation of Diamond Hill Fresh Water and Salt Water Service Reservoirs to Caverns



水務署計劃在2014年年底展開項目的可行性研究，預計需時2年。

Water Supplies Department will commence the Feasibility Study by end 2014. The study will take 2 years to complete.

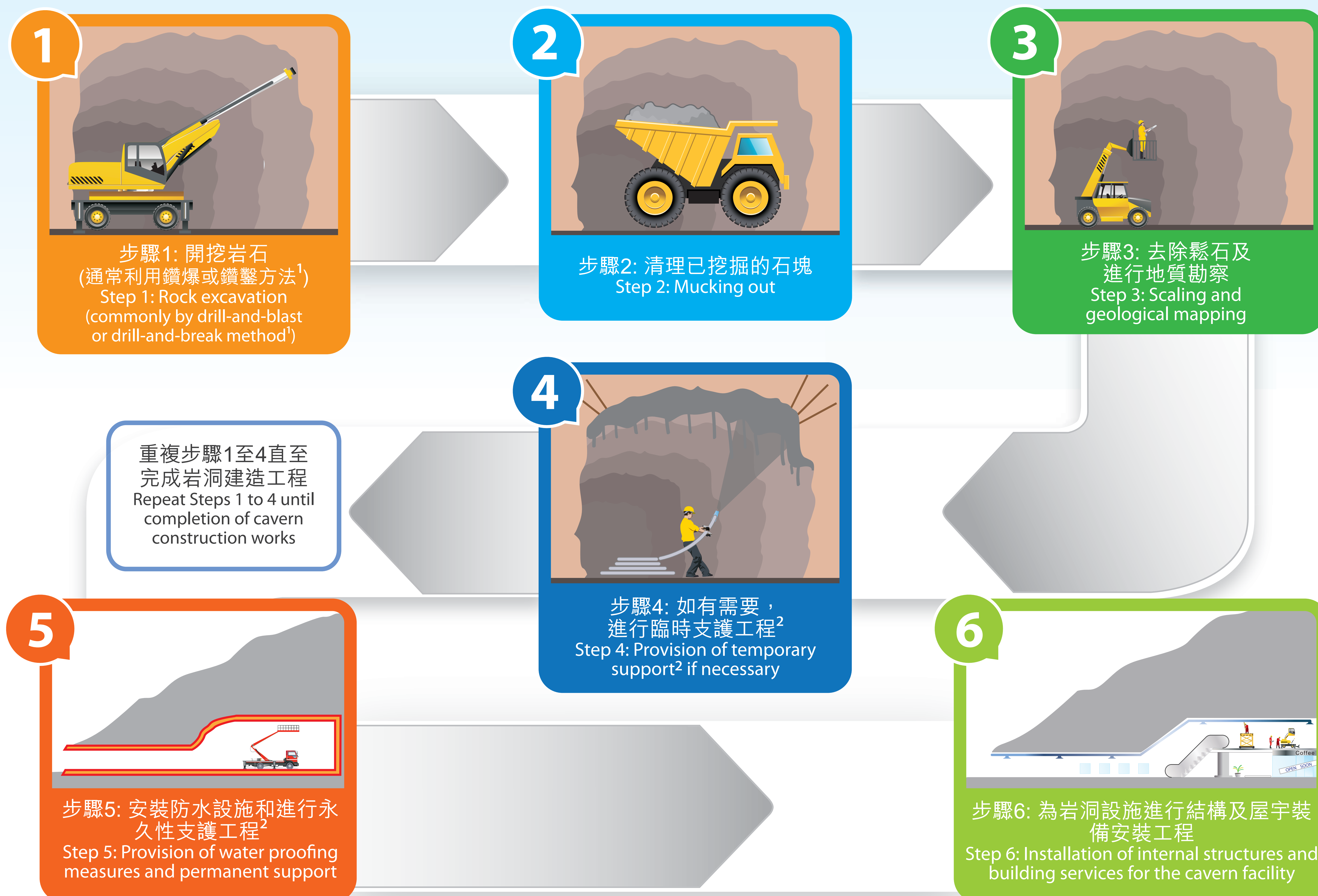




# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 如何建造岩洞？ How to Construct a Cavern?

### 建造岩洞的主要步驟 Key Steps of Cavern Construction Works



### 小知識Tips



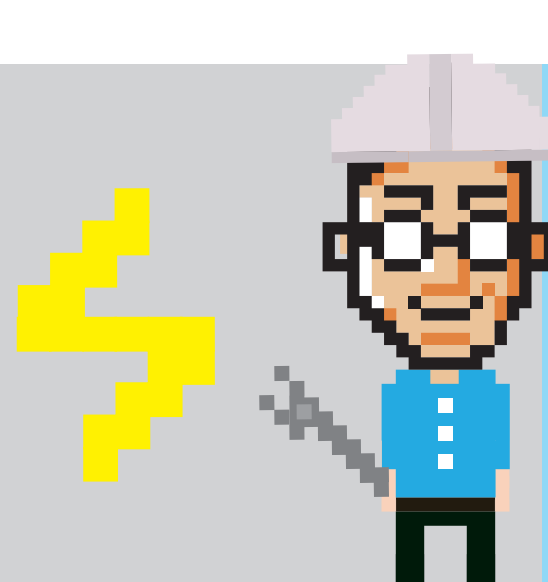
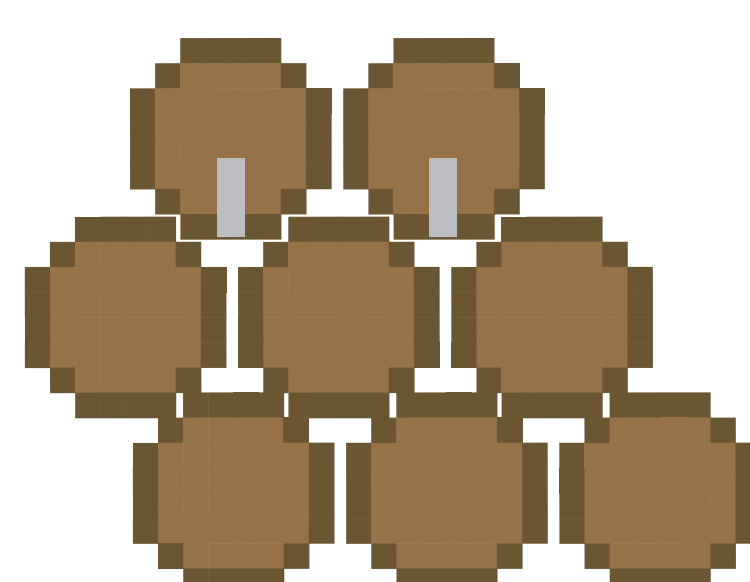
鑽爆方法採用炸藥爆破岩石，效率較高但可能會造成震盪。鑽鑿方法利用機械打碎岩石，震盪較少但需時可能較長。

Drill-and-blast method uses explosives for breaking of rock, which is more efficient but may induce more vibration. Drill-and-break method uses machinery for breaking of rock, which induces less vibration but may require more time.



臨時支護旨在提供安全環境以進行挖掘工程，永久性支護則處理岩洞結構的長遠穩定性。岩層錨杆和噴漿均可用作臨時或永久性支護，混凝土襯砌可為不利地質條件的地方提供永久性支護。

Temporary support is to ensure safe working conditions during cavern excavation. Permanent support is to ensure long-term stability of the cavern structure. Rock bolts and shotcrete may be used for both temporary and permanent support. Concrete lining may be provided as permanent support for areas of poor ground conditions.





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## 技術挑戰與解決方案 Technical Challenges and Solutions

### 環境影響 Environmental Impact

- 根據環境影響評估條例，岩洞項目必須進行環境影響評估。由於工程主要於岩體內進行，只要實施適當的紓減措施，可有效減低對附近環境的影響。
- 地下水流入岩室或會令地下水位下降，影響地面生態環境。透過審慎選址以避免開挖脆弱地層、進行土質改善工程、安裝防水系統等措施，均有效處理地下水流入的問題。
- 岩洞發展可避免大型削切山坡的需要，因此能保留周遭的自然環境，包括植被和生態環境。開挖的石材亦可用作建築物料，大大減少建築廢料的產生。
- 西區海水配水庫和赤柱污水處理廠的例子，可展示岩洞設施如何能融入附近的自然環境。
- Cavern projects are required to carry out an Environmental Impact Assessment under the Environmental Impact Assessment Ordinance. Given that most construction activities are within the rock mass, with the implementation of appropriate mitigation measures, the environmental impact can be effectively minimised.
- Inflow of groundwater into the underground excavation may draw down the groundwater table and affect the ecological habitats on the surface. The effect can be minimised by careful site selection to avoid weak zones, implementation of ground improvement works and installation of a water proofing system.
- As compared to surface development, cavern development can avoid the need for massive hillside excavation, thus preserving the natural landscape, including vegetation cover and ecological habitats. The excavated rock can also be processed as construction materials, thus significantly reduce the production of construction wastes.
- Western Salt Water Service Reservoirs and Stanley Sewage Treatment Works are good examples to demonstrate how cavern facilities can blend in with the surrounding environment.

### 消防安全 Fire Safety

- 由於岩洞內煙霧和熱力易於積聚，而且逃生路程一般較長，消防安全因而成為岩洞發展的其中一項重大挑戰。
- 須考慮相關消防安全規定(包括逃生途徑、消防和救援進出途徑、耐火結構、消防裝置及設備等要求)，制定全面的消防安全策略以進行詳細設計，並訂立有效的消防安全管理計劃供設施運作階段推行。
- 近年，一些大型的港鐵車站也是建於岩洞內，故此，提供很多處理消防安全的寶貴經驗作參考。
- Fire safety is a great challenge in cavern development as smoke and heat can accumulate inside caverns and escape routes can be relatively long.
- It is necessary to consider relevant fire safety requirements (e.g. means of escape, means of access for firefighting and rescue, fire service installations and equipment and fire resisting construction) in formulating a comprehensive fire safety strategy for carrying out detailed design. An effective fire safety management plan should also be developed for implementation during the life of a facility.
- Currently, several large MTR stations are being built in caverns, thus providing valuable experience for dealing with fire safety issues.

### 通風 Ventilation

- 岩洞內必須裝置充足的通風設備，以提供安全及舒適的環境和配合設施運作的需要。
- 因應個別設施的要求，可建造豎井加強空氣流通。
- 透過適當設計的通風系統，可有效提昇岩洞內的空氣質素，並解決氡氣積存等問題。
- It is essential to provide adequate ventilation to maintain a safe and comfortable environment within caverns and meet the operational needs of a facility.
- Based on individual facilities' requirements, shafts may be employed to improve air circulation.
- A properly designed ventilation system can effectively improve air quality in caverns and prevent problems such as accumulation of radon gas.

### 其他挑戰 Other Challenges

- 岩洞挖掘工程一般會產生不同程度的震盪及出現地下水流入的情況。如沒有適當控制，震盪有機會影響附近的建築物，而地下水流入或會令地下水位下降，造成地面沉降。
- 施工期間，附近的交通亦可能受到影響。
- 須進行相關評估，並為項目制定合適的施工準則及紓減方案。透過嚴格的施工監察，工程帶來的影響將可減至最低。
- Cavern excavation works would generally induce certain amount of vibration and groundwater inflow. Without proper control, vibration may affect adjacent building structures and groundwater inflow may draw down the groundwater table, causing ground settlement.
- Nearby traffic may also be affected during construction period.
- It is necessary to carry out related assessments and formulate appropriate specifications and mitigation schemes for the projects. By closely monitoring the construction works, the potential adverse impact can be kept to a minimum.





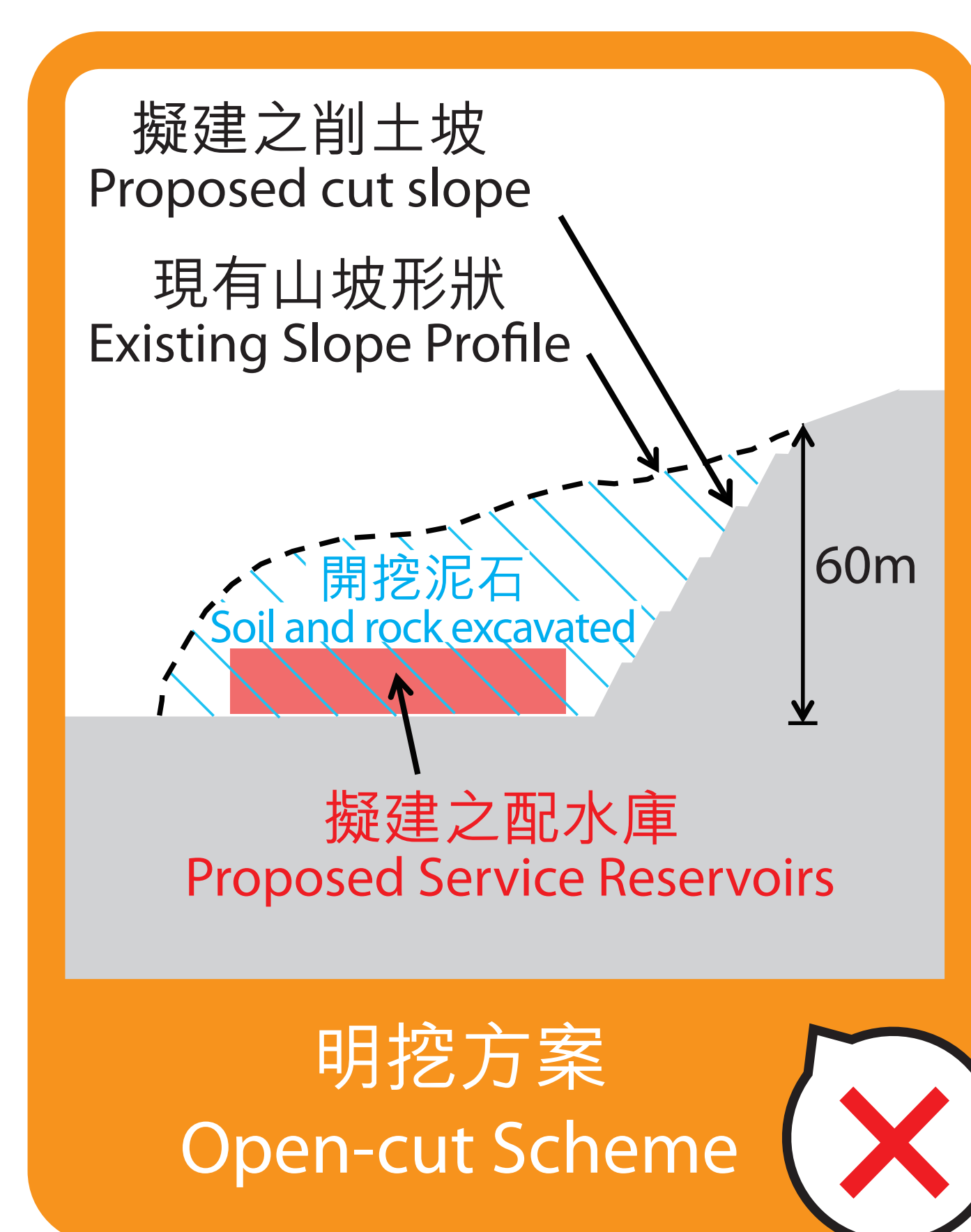
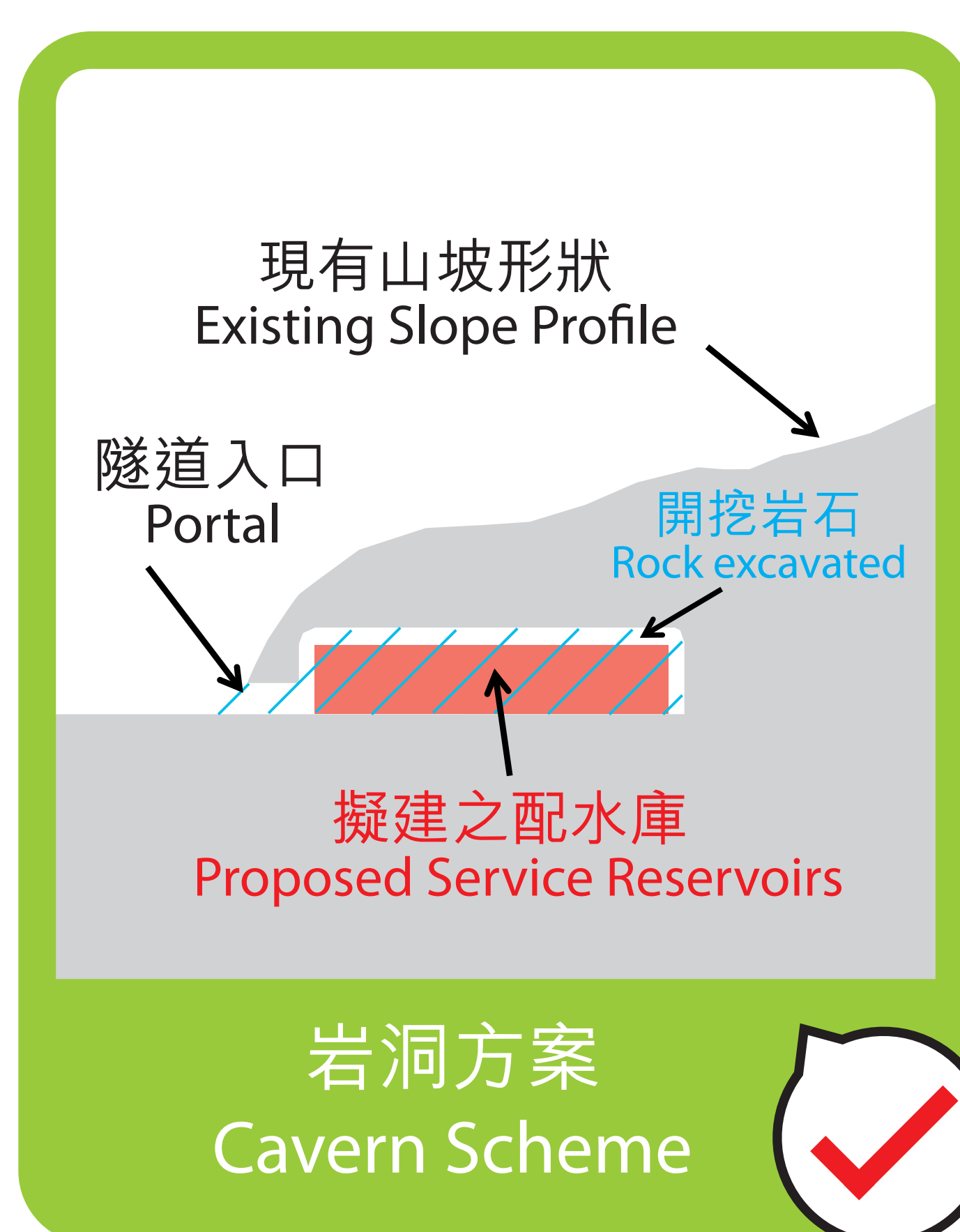
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## 香港岩洞項目的成功實例 - 搬遷西區海水配水庫往岩洞

### A Successful Rock Cavern Project in Hong Kong - Relocation of Western Salt Water Service Reservoirs to Caverns

香港大學於2009年將兩個水務署海水配水庫 (共12,000立方米容量) 遷移至岩洞內，以騰出地面土地，發展百周年校園。相比明挖方案，岩洞方案保存了附近三座歷史建築物和顯著減低對環境及景觀的影響，包括減少伐樹量以及對次生林生態的影響，並減少八成半挖掘物料數量。

In 2009, the University of Hong Kong (HKU) relocated two Water Supplies Department salt water service reservoirs (total 12,000 m<sup>3</sup> capacity) to rock caverns, thereby releasing the surface land for development of their Centennial Campus. As compared to the open-cut scheme, the cavern scheme preserved three historic graded buildings nearby and significantly alleviated the environmental and visual impacts, including minimising tree felling and ecological impact to the secondary woodland and reducing the amount of excavated materials by 85%.



#### 岩洞資料 Cavern Information

岩室 (共2個)	- 約50米長 x 17米闊 x 17米高
隧道通道	- 約65米長 x 7米闊 x 7米高
挖掘體積	- 約33,000立方米
建造方法	- 鑽鑿方法
Cavern halls (2 no.)	- About 50 m (L) x 17 m (W) x 17 m (H)
Access tunnel	- About 65 m (L) x 7 m (W) x 7 m (H)
Excavation volume	- About 33,000 m <sup>3</sup>
Construction method	- Drill-and-break method





# 岩洞發展長遠策略展覽 Exhibition on Long-term Strategy for Cavern Development

## 地下空間發展策略 Underground Space Development Strategy

 <p>於市區發展地下空間 Underground Space Development in Urban Areas</p> <p>於市區邊緣發展岩洞 Rock Cavern Development at Urban Fringes</p>	<p>於市區邊緣發展岩洞 Rock Cavern Development at Urban Fringes</p> <table border="1"> <tr> <td>建造方法 Construction Method</td> <td> <ul style="list-style-type: none"> <li>開挖岩石 Excavation in rock</li> </ul> </td> </tr> <tr> <td>規劃和發展好處 Planning and Development Gains</td> <td> <ul style="list-style-type: none"> <li>興建合適公私營設施 House suitable public or private sector facilities</li> </ul> </td> </tr> </table>	建造方法 Construction Method	<ul style="list-style-type: none"> <li>開挖岩石 Excavation in rock</li> </ul>	規劃和發展好處 Planning and Development Gains	<ul style="list-style-type: none"> <li>興建合適公私營設施 House suitable public or private sector facilities</li> </ul>	<p>於市區發展地下空間 Underground Space Development in Urban Areas</p> <table border="1"> <tr> <td> <ul style="list-style-type: none"> <li>主要開挖軟土 Excavation mainly in soft ground</li> </ul> </td> </tr> <tr> <td> <ul style="list-style-type: none"> <li>增加可用空間 Creating usable space</li> <li>優化區內連接性 Enhancing district connectivity</li> <li>改善社區環境 Improving the community environment</li> </ul> </td> </tr> </table>	<ul style="list-style-type: none"> <li>主要開挖軟土 Excavation mainly in soft ground</li> </ul>	<ul style="list-style-type: none"> <li>增加可用空間 Creating usable space</li> <li>優化區內連接性 Enhancing district connectivity</li> <li>改善社區環境 Improving the community environment</li> </ul>
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