Rock Caverns – Hong Kong's Hidden Land

K.C. Ng[1], K.J. Roberts[2] and Y.K. Ho[3]
[1,2,3]*Geotechnical Engineering Office, Civil Engineering and Development Department, The Government of the Hong Kong Special Administration Region*
[1]*E-mail*: samuelkcng@cedd.gov.hk
[2]*E-mail*: kjroberts@cedd.gov.hk
[3]*E-mail*: tonyykho@cedd.gov.hk

ABSTRACT: The hilly terrain and underlying geology of Hong Kong offer an excellent opportunity for placing urban facilities underground. About two-thirds of Hong Kong's land is found to be suitable for rock cavern development. Given the potential for multi-layer cavern development, a substantial usable area could be created. In September 2012, the Civil Engineering and Development Department of the Government of the Hong Kong Special Administrative Region commenced a study on "Long-term Strategy for Cavern Development", to develop a holistic approach in planning and implementing cavern development and render it a sustainable means for expanding land resources. The study also places emphasis on private sector participation as facilities, such as storage, warehousing and data centres, can benefit from rock caverns' stable and secure setting. Implementation of a long-term strategy for cavern development could provide a sustainable approach in easing the pressure of land shortage. Developing a systematic relocation programme for suitable Government facilities could release surface sites for other uses including housing, and placing nuisance or potentially hazardous facilities in caverns could remove incompatible land uses. Reserving rock cavern space to accommodate future public and private sector facilities underground could further reduce the land take. The Hong Kong Government has also commenced an initiative to explore the potential of underground space development in the urban areas. Facilitating rock cavern development at the urban fringes and underground space development in the urban areas could enhance Hong Kong's utilisation of land resources in pursuit of sustainable development.

1. INTRODUCTION

Hong Kong's topographical setting with steep natural hillsides pose significant constraints to development (Figure 1). Land, particularly in the urban areas, is a scarce resource. To support social and economic development, there is a pressing need to increase the supply of land and optimise the usage by sustainable and innovative approaches. One possible way is through rock cavern development for suitable types of land use.

Figure 1 Aerial View of Hong Kong Island

In October 2009, the Chief Executive of the Government of the Hong Kong Special Administrative Region (HKSAR) presented the 2009-10 Policy Address on "Breaking New Ground Together". The Development Bureau put forward a new initiative under the Policy Agenda of 'Developing the Infrastructure for Economic Growth' to launch strategic planning and technical studies to facilitate planned development of underground space, which are aimed at promoting the enhanced use of rock caverns as part of Hong Kong's pursuit of sustainable development. In the 2013 Policy Address on "Seek Change, Maintain Stability - Serve the People with Pragmatism", the Chief Executive highlighted that rock cavern development is a viable source of long-term land supply and stressed the need to conduct a study on the long-term strategy for cavern development with a view to preparing rock cavern master plans and formulating policy guidelines. In addition to moving ahead with cavern development, the 2014 and 2015 Policy Addresses highlighted the need to explore the potential for developing underground space with a view to increasing usable space and enhancing connectivity in the urban areas.

This paper examines the potential of rock caverns as a valuable land resource for Hong Kong, in light of the policy support for its development, and the work in progress in order to realise this potential. The paper (i) summarises the findings of a recently completed cavern study, (ii) establishes the hidden land resource from cavern development, (iii) examines the background and constraints to cavern development, (iv) outlines the scope and expected outcomes of the current study on long-term strategy for cavern development, and (v) describes the new initiative on developing urban underground space.

2. STUDY ON ENHANCED USE OF UNDERGROUND SPACE IN HONG KONG

A scoping study on "Enhanced Use of Underground Space in Hong Kong", hereafter referred to as the "Cavern Study", was commissioned by the Geotechnical Engineering Office of the Civil Engineering and Development Department (CEDD) in March 2010 to take forward the policy initiative of rock cavern development as laid out in the 2009-10 Policy Agenda. The study, which was completed in March 2011, explored the opportunities to enhance the effective use of land resources in Hong Kong from a new perspective through the planned development of underground space. The study is summarised by Chan (2011) and the Executive Summary of the study has been made publicly available (ARUP 2011). The key findings were as follows:

- Hong Kong is suitable for developing rock caverns from a geological perspective. The hilly areas in the urban fringes of Hong Kong with strong rocks and convenient access are particularly suitable.
- By reprovisioning suitable Government facilities inside caverns and releasing the original land as well as any adjacent sterilized land for housing and other uses, cavern development is a viable option to increase land supply.
- Cavern development could also accommodate new infrastructure facilities which would otherwise occupy surface land. Reserving underground space could cater for future projects and expansion of underground facilities.
- For those nuisance facilities like sewage treatment works or potentially hazardous installations like oil terminals, the cavern

option would help reduce adverse impacts on the local environment, remove incompatible land uses and alleviate the "Not In My Back Yard" (NIMBY) sentiment.

3. HONG KONG'S HIDDEN LAND

The Cavern Study has identified that two-thirds of Hong Kong's land is of medium to high suitability for cavern development (Figure 2), adopting a Geographic Information System Approach for regional mapping (Wallace et al. 2014). Comparatively, those areas closest to the urban fringes have higher potential due to the relatively easier access from existing transport networks and lower excavation and support costs for the relatively shorter access tunnels to proposed cavern developments. These urban fringe areas are also generally not compromised by private land ownership issues.

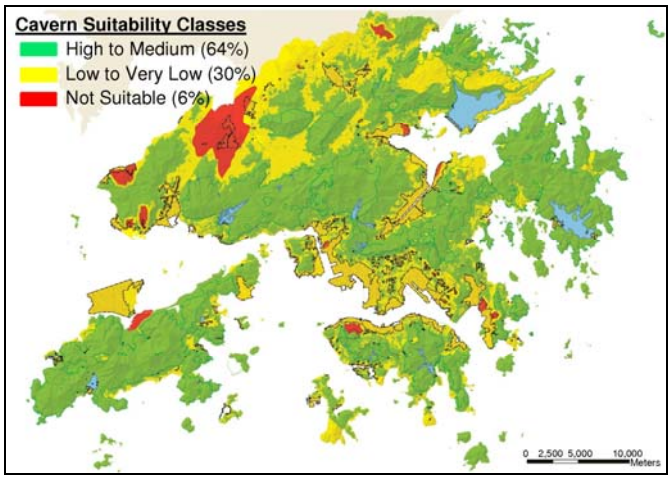

Figure 2 Distribution of Cavern Suitability Classes

Making a simple estimation, that two-thirds of Hong Kong's land area (1,104 km^2) is considered suitable for cavern development, this would amount to some 700 km^2 (70,000 ha). Conservatively assuming that only 10% of this area (7,000 ha) is readily accessible within the urban fringes due to access or land ownership issues, and allowing a further 50% reduction to cater for intervening rock pillars for support, this could still provide some 3,500 ha of developable land in plan area. If we think three-dimensionally, a multiplier effect may also be realised by vertically stacking caverns at different elevations and also by forming multiple floors within a single cavern to increase gross floor areas, as illustrated in Figure 3.

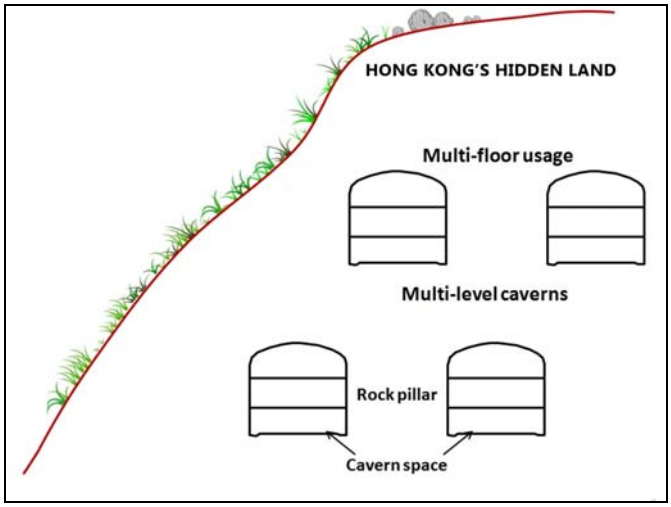

Figure 3 Vertically Stacked Caverns with Multi Level Layout

As the land area occupied by existing Government facilities considered suitable for cavern development is around 400 ha, relocating those facilities in caverns could release the land for other uses. Relocation of NIMBY facilities can also enhance the value of neighbouring land. For existing Government facilities, the released sites are usually not very large (say 1-2 ha) but are still attractive as they are generally close to urban areas with good infrastructure support and hence can be readily turned to developable land without much works required. However, it is recognised that housing certain large Government facilities in caverns will still require resolving some specific technical issues (e.g. fire safety for sports facilities, treatment technology and ventilation for water treatment works), and therefore it will take a longer lead time to realize their potential.

Given that some 3,500 ha of land may be formed from cavern development, and that the existing Government facilities considered suitable for cavern development only occupy around 400 ha, there is considerable scope for developing new public and private sector facilities in caverns, thereby reducing the future land take. The Cavern Study reviewed overseas practice and recommended other potential land uses for cavern development for inclusion in the Hong Kong Planning Standards and Guidelines (PlanD 2008), as shown in Table 1. It is considered that some cavern facilities may have opportunities for private sector participation, if appropriate, and therefore suitable enabling or facilitating mechanisms should also be established.

Table 1 Potential Land Uses for Cavern Development

Land Use Category	HK Planning Standards & Guidelines (PlanD 2008)	Additional Potential Land Use (ARUP 2011)
Commercial	Retail	Food/Wine storage Warehousing
Industrial	Industry Storage/Warehousing Oil bulk storage LPG bulk storage	Dangerous goods Data centre Research laboratories Science park
Government / Institution / Community (GIC)	Civic centre Indoor games/Sports Hall Incinerator Refuse transfer facility Service reservoir Sewage/Water treatment plant Slaughterhouse Wholesale market Transportation connections & networks Columbarium/mausoleum /mortuary	Archives Bicycle park-and-ride Car/Vehicle parking Crematorium Refuse collection point Maintenance depot, e.g. rail and bus Underground quarry
Public Utilities	Power station	Substation

4. HISTORY OF CAVERN DEVELOPMENT

Hong Kong has a rich legacy of underground tunnelling. During its development, some 430 km of tunnels have been constructed and some 180 km are planned up to 2020 (Pang & Woodrow 2009). These underground structures cater for water supply, mass transportation (such as railways and roads), drainage, conveyance of sewage and electrical cables. Hong Kong also has a diversity of deep basement-type excavations formed by cut and cover methods for MTR station concourses, car parks, retail and commercial space and more recently storage tanks for flood control.

Cavern construction is an established technology that has shown continual improvement in its application (NRC 2013). Since the 1980s, the Government of the HKSAR has carried out the necessary

technical and preparation work for cavern development in Hong Kong (e.g. Neste 1982; ARUP 1990). Technical standards on cavern engineering and fire safety design (GEO 1992; BA & FSD 1994; BD 1995), as well as planning guidelines to establish the ground work for rock cavern development, have been published. These have been outlined by Chan and Ng (2006).

A few purpose-built rock caverns were constructed in the mid-1990s to accommodate public facilities to meet the needs of the community (Figure 4), namely the Stanley Sewage Treatment Works in 1995, and Island West Refuse Transfer Station and Kau Shat Wan Explosives Depot in 1997. Also in 2009, the University of Hong Kong reprovisioned the Western Salt Water Service Reservoirs in rock caverns to release 2 ha of land, occupied by the service reservoirs as well as the adjacent land, for the Centennial Campus development, which includes three buildings for the Faculty of Arts, Faculty of Law and Faculty of Social Sciences.

Yet, these facilities, which are a testament to their success, remain relatively unknown to the general public. They are predominantly NIMBY facilities, which are now effectively hidden underground (Figure 5), with minimal visual and environmental impact and thereby attract very few complaints. Furthermore, relocating the Western Salt Water Service Reservoirs to rock caverns provided a sustainable and environmentally friendly solution as compared to the original open-cut scheme. The amount of excavation in soil and rock was significantly reduced to one seventh of the original scheme and substantial areas of woodland were saved, in addition to preserving three graded historic buildings.

It is evident that rock caverns can be cost-effective, through releasing valuable surface land for other beneficial uses, and in some cases, yield additional environmental, safety and security benefits. Nevertheless, the exploitation of cavern schemes to house suitable facilities in Hong Kong has generally been limited. In general, rock cavern development is either out of necessity or done as a last resort in circumstances where suitable surface land is not available.

The feedback of Government consultative bodies and the public response to the initiative of enhancing the use of rock caverns as part of Hong Kong's pursuit of sustainable development was generally positive (CEDD 2013). However, there remains a general feeling that this type of development is more suited for NIMBY facilities, which is likely to be due to perceived psychological impacts of going into a dingy, unpleasant underground space.

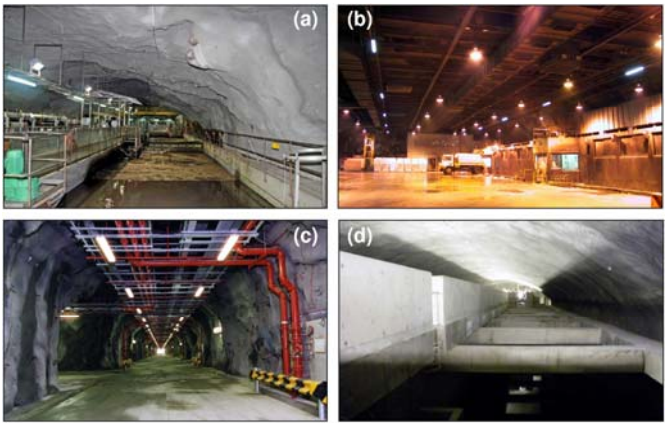

Figure 4 Examples of purpose-built caverns in Hong Kong: Stanley Sewage Treatment Works, (b) Island West Refuse Transfer Station, (c) Kau Shat Wan Explosives Depot and (d) Western Salt Water Service Reservoirs

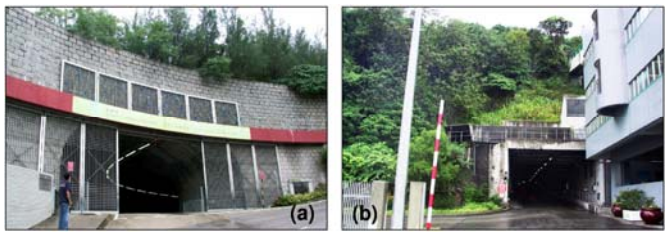

Figure 5 Cavern portals of (a) Stanley Sewage Treatment Works and (b) Island West Refuse Transfer Station

5. GENERAL PERCEPTION OF CAVERN ENVIRONMENTS

Goel et al. (2012) described some of the psychological and physiological considerations of working or living underground, including fear of darkness, disorientation, entrapment, negative associations to burial and death, lack of natural light and ventilation, etc. Despite the above possible concerns, the fact is that a significant proportion of the general public use underground space on a daily basis, but may be unaware of this due to the pleasant and well maintained surroundings.

Using the Mass Transit Railway (MTR) as an example. Ling (2011) reported that the pedestrian subways between the Central Station and Hong Kong Station have a daily pedestrian flow of 120,000, while the subway system connecting the Tsim Sha Tsui Station and Tsim Sha Tsui East Station handles some 170,000 pedestrians daily. Around 200,000 passengers use the Tai Koo Station and Sai Wan Ho Station daily, which are wholly formed within rock caverns constructed in the 1980s. New MTR cavern stations include the recently completed Hong Kong University and Sai Ying Pun Stations of the West Island Line, and Admiralty and Lei Tung Stations of the South Island Line which are now under construction. A combined daily pedestrian flow of these stations is estimated at over 200,000 by 2031.

In addition, Hong Kong has many notable basement developments within the urban areas that contain retail developments, vehicle parking, etc., that are widely used by the general population. Goel et al. (2012) noted that the windowless nature of a department store does not seem to bother people as much as with other functions due to a continual contact with people as well as constant activity. There are in fact many other facility types that are well suited to and therefore designed as a windowless environment, including museums, theatres, libraries, gymnasiums and laboratories.

Based on overseas experience, it is considered that there is significantly more potential to utilise rock cavern development in Hong Kong, for a much wider range of facilities than are currently in use. This will require efforts to alleviate the negative psychological and physiological concerns through appropriate architecture and design strategies and techniques, many of which have already been successfully employed in various underground buildings in Hong Kong. Some pragmatic measures are provision of an above-grade building or notable entrance to form a smooth and pleasant transition from the surface to underground space, use of a higher ceiling than typical one-storey height to give a sense of space, adoption of beamed daylight system or full-spectrum artificial lighting, and creation of a positive environment using warm, bright colours, plants, water features and artwork.

6. CONSTRAINTS ON AND BENEFITS OF CAVERN DEVELOPMENT

The Cavern Study has benchmarked Hong Kong's practice against worldwide practice, and has raised the issue of whether we can do more and how the Government of the HKSAR can take forward the initiative. A number of key constraints were identified for cavern development in Hong Kong (Roberts & Ng 2012) and these can be broadly grouped under two main categories, unfavourable regulatory mechanism and unfavourable financial assessment, as listed in Table 2.

Despite the promulgation of planning and technical guidelines on rock cavern development in Hong Kong in the early 1990s, there has been no systematic assessment of the potential and the benefits of rock cavern development in the land use planning process and the development of public works projects, as demonstrated by the few public facilities that have been housed in rock caverns. The Hong Kong Planning Standards and Guidelines (PlanD 2008) with regard to rock cavern development, first published in 1991, were revised in 2008 to highlight the need to identify the opportunities at the early stage of the land use planning process and to assess the cavern option at the initial project planning stage for new project proposals, as well as to set out some of the implementation issues affecting rock caverns. Despite the promulgation of the revised guidelines in 2008, there is still slow progress in the planned use of rock cavern developments.

Table 2 Constraints on Rock Cavern Development

Unfavourable Regulatory Mechanism	Unfavourable Financial Assessment
• Policy guidelines • Planning & zoning policies • Land ownership framework • Mechanism for valuation of cavern space • Project benefits may not reflect community benefits	• Cost of land formation excluded • Value of the land & adjacent sterilised land not considered • Land value enhancement by relocating NIMBY facilities not considered • Opportunity and intangible costs (e.g. less complaint handling) not considered

In Hong Kong, the owner of the surface land also owns to the sky and to the depths and has the right to develop its underground space. Underground development for public purposes can be developed underneath private lots pursuant to the relevant Ordinances (e.g. Lands Acquisition Ordinance, Land Resumption Ordinance), subject to compensation to the land owner. Conversely, privately orchestrated underground development cannot be developed beneath private lots under the ownership of others.

The development model for many of Hong Kong's projects is of a mixed-use type and the ownership of the land is often amongst multiple parties. From an administrative viewpoint, it would be difficult to organize all of the owners to consent to the underground development beneath these land plots. To avoid complicated and potentially contentious land ownership issues, it is preferable to develop caverns to house Government facilities beneath areas where there is no private ownership. In this respect, the hillsides in the urban fringes are particularly suited for cavern development.

To facilitate optimal underground development, a revised regulatory framework would be required. The amendments would include the ability to create separate ownership between surface and underground developments. However, this would only be an option in case of newly disposed land and legislative amendments may be required for the interfacing between joint land owners.

It is recognised that each individual public works project by its very nature must have a public demand and public support. Whether a particular facility should be located within caverns is largely left to the individual facility providers to decide (Ling 2011). One of the key concerns amongst potential end users is the general perception that caverns are more expensive in terms of both capital and operating/maintenance costs. It is likely that in some cases operating/maintenance costs can be expected to be higher, which is mainly a result of the additional energy costs associated with lighting and ventilation for an underground facility, depending on their nature. However, most buildings in Hong Kong also require lighting and ventilation. Furthermore, temperatures within caverns generally remain stable in the range of 20°C to 25°C all year round as compared to the mean surface temperatures varying between 15°C in winter and 31°C in summer. Therefore, a significant reduction in air-conditioning cost can be expected for a facility placed in caverns, particularly if a uniform temperature environment is required for efficient operation. Energy efficient initiatives could also be adopted to further reduce energy consumption and achieve environmental friendly objectives.

When a new MTR station is publicly announced, this has a generally positive effect, which is often reflected by a sudden jump in property prices in the immediate vicinity. Can it therefore be assumed that locating or removing a nuisance facility such as a sewage treatment works or refuse transfer station, or a potentially hazardous installation such as an oil terminal to a more remote location away from the urban area would also have a positive effect on the surrounding developments? Is this something that can be quantified and included in an economic assessment as an overall community benefit that could far outweigh the higher project costs by adopting cavern development?

The present economic analysis for assessing the cost of a specific Government facility has assumed that the land is provided at no extra cost to the facility provider. This has resulted in any cost comparison between the surface and cavern option being skewed in favour of the surface option. Take, for example a new Government facility planned for development in an area of reclaimed land adjacent to steep hillsides where the cavern option may also be considered. In comparing the costs, as cavern construction, which is a form of land development, is an integral part of the works, it is normally included in the overall cost of the facility. However, the previous cost of formation of the reclaimed area prior to the project implementation is invariably not considered as part of the overall cost in the surface option resulting in an inequitable comparison.

The analysis has also not taken into account the opportunity cost of any alternative use of that specific site or the cost of any adverse impact or sterilisation on the potential use of the neighbouring sites (Ling 2011), i.e. in building the facility at that location, Hong Kong has forgone the opportunity to build other facilities to meet the community's needs, or to improve the local environment by freeing up land for other community uses.

Many of the benefits of cavern development to the community are intangible, e.g. additional open space and reduced congestion or likely reduction in complaints. For nuisance or potentially hazardous facilities which are needed to support the needs of the community, they can be located away from the public eye if they are placed underground. Examples are the Stanley Sewage Treatment Works and Island West Refuse Transfer Station, where the daily operations have been effectively shielded from the public view to the extent that many of the local population are unaware of their existence (Figure 5). There is currently no framework to take intangible benefits into account to offset the additional costs associated with cavern development, and the overall benefit to the community is often overshadowed by the immediate public needs of a project.

Only by overcoming the constraints can the full benefits of rock cavern development be realised, some of them are given in Table 3. These can be related to the broader issues of land supply, land use compatibility and the environment, or be specific to facility type.

Table 3 Benefits of going underground

Benefits	Examples
• Enhancing land supply	• Release surface land for other uses through relocation of existing facilities and placing of new facilities
• Protection of environment	• House nuisance facilities (e.g. sewage treatment works) away from public view
• Stable and secure conditions	• Favour goods storage, data centres, archives, etc
• Flexibility in layout and geometry	• Favour warehousing and logistics, etc
• Flexibility for future expansion	• 3-D environment can be reserved (e.g. vertically and laterally)
• Removal of incompatible land uses	• Locate NIMBY facilities away from developed areas (e.g. refuse transfer station, columbarium)
• Source of rock products	• Re-use of excavated rock materials

7. ROAD MAP FOR CAVERN DEVELOPMENT

To take forward the cavern initiative as a sustainable means for increasing land supply, the CEDD commenced a study on the "Long-term Strategy for Cavern Development", hereafter referred to as the "Strategic Study", in September 2012 for completion by late 2015. In parallel, four pilot relocation schemes, namely Sha Tin, Sai Kung and Sham Tseng Sewage Treatment Works, and Diamond Hill Fresh Water and Salt Water Service Reservoirs, are being studied for their technical feasibility and financial viability. These facility specific studies together with the Strategic Study form the roadmap for cavern development (Figure 6).

The formulation and implementation of a long-term strategy for cavern development would provide a systematic and sustainable approach in easing the pressure of land shortage in Hong Kong, particularly in the urban areas. Apart from nuisance or potentially hazardous facilities, opportunities for housing a wide variety of suitable Government and private sector facilities in rock caverns are plentiful and evident elsewhere (e.g. Vähääho 2011; Zhou & Cai 2011).

The prime objective of the Strategic Study is to develop a holistic approach in planning and implementing rock cavern development. The key items of this study and the expected outcomes are summarised below.

Figure 6 Road Map for Rock Cavern Development

7.1 Formulation of policy guidelines

Policy guidelines will be formulated to facilitate cavern development for both public and private sectors. The study will aim to develop a proactive policy for cavern development to mandate Government departments to consider the cavern option at the initial project planning stage for suitable facilities, and to facilitate private sector participation in cavern development.

An important element is to develop an appropriate method of economic analysis for comparing cavern and surface site options on an equitable basis, taking account of factors such as the value of the surface land, cost of land formation, value of excavated materials for re-use, value of sterilised land nearby, enhancement of land value in the vicinity, opportunity cost of the surface site, cost impact on maintenance and operation, and other intangible benefits.

7.2 Preparation of Cavern Master Plans

A territory-wide Cavern Master Plan is being prepared to delineate strategic cavern areas in terms of geotechnical considerations and the current planning perspectives for compatible land uses for future Government facilities and suitable private sector land uses. Thus far, some 50 strategic cavern areas have been delineated, covering a total plan area of about 50 km^2 (5,000 ha). Implementation mechanisms are also being developed for reserving these areas such that their potential for cavern development will not be compromised by future surface or underground development projects.

The plans will include cavern locations for re-housing suitable Government facilities and the associated existing transport links, corresponding protection zone, any known and planned surface and underground facilities or development projects above and within the strategic cavern areas, and suitable private sector land uses that could be considered for locating within the strategic cavern areas. Special issues, such as traffic and transport, environmental and land ownership, will also be highlighted in the relevant explanatory statement and information note.

7.3 Formulation of a systematic relocation programme

A systematic programme is being developed for relocation of suitable Government facilities to caverns in a planned manner, thereby gradually releasing the surface land for other uses. This will take account of their status, e.g. plans for expansion or re-provisioning, so as to develop a workable schedule that meets the needs of Government departments and community expectations.

Broad planning, technical and financial assessments will establish the preliminary technical feasibility and financial viability. Key issues that need to be further considered in future detailed feasibility studies will be identified. Suitable time frame for their implementation will be considered in accordance with the requirements of individual facility owners.

7.4 Development of mechanisms for private sector participation

This aims to explore the demand for use of rock caverns by undertaking consultation and survey with relevant stakeholders for suitable private sector land uses, and to facilitate private sector participation. The study will place emphasis on private sector involvement as an integral part of the cavern initiative, because many private facilities, such as storage, warehousing and data centres, can benefit from a stable and secure setting offered by rock caverns. If the private sector embraces this initiative, this could significantly reduce the land take for these facilities in the future. In general, there is strong interest from private sector for leasing and developing cavern space for usage such as warehousing and logistics, wine storage, data centres and columbaria.

Apart from facilitating policy, strategy and procedures, enabling schemes adopted in some overseas countries, including direct Government funding, low land premiums, cash grant or tax

incentives, as well as Public Private Partnerships, may be considered. The suitability of these enabling schemes for Hong Kong's situation will be examined through outline feasibility studies for housing a warehouse/logistics facility, data centre, columbarium, vehicle depot, archives, research laboratory and a shopping arcade in rock cavern (Ross et al. 2014).

7.5 Formulation of a framework for cavern ownership

The opportunity for separate ownership for surface and cavern developments for future land disposals will be explored, so as to facilitate optimal underground development. This aims to review the overseas practice and arrangements currently being used in respect of separate ownership for surface and cavern developments, review the land ownership issues with respect to underground development including relevant Ordinances, and recommend a suitable framework for Hong Kong conditions.

7.6 Review of technical issues

Several key issues that are crucial for cavern development will be considered under the study, which include:

(a) updating of Geoguide 4: Guide to Cavern Engineering which was published in 1982,
(b) reviewing the limits on blasting vibrations in Hong Kong,
(c) preparing conceptual fire safety designs and fire safety management plans for high population density facilities (columbarium and indoor sports hall in caverns),
(d) reviewing the key technical issues of housing water treatment works and service reservoirs in caverns,
(e) recommending appropriate contract forms for implementing cavern development, and
(f) carrying out a Strategic Environmental Assessment for cavern development.

Resolving these issues will help maximize the opportunities to use rock caverns for housing a wider range of facilities, some of which can take up a large area of surface land.

7.7 Public consultation with stakeholders

These will be undertaken to gauge public/stakeholders' views and foster understanding and acceptability of the policy guidelines to facilitate cavern development, the Cavern Master Plans, the systematic relocation programme for re-provisioning suitable Government facilities to rock caverns, mechanisms for private sector participation and specific issues as identified during the course of the study.

8. OTHER UNDERGROUND OPPORTUNITIES

In the 2014 and 2015 Policy Addresses, the Chief Executive highlighted that, apart from rock caverns, urban underground space is a viable source of long-term land supply (Figure 7). Ling and Chan (2013) advocate that the use of underground space is very limited in Hong Kong and it is worth retrofitting the underground space in urban Hong Kong to provide a sustainable solution to some of its urban issues such as over-congestion.

The Hong Kong SAR Government has initiated two separate studies exploring the opportunities of underground space development in the urban areas, specifically with a view to creating space for commercial and other uses and enhancing connectivity in the urban areas, thereby improving the congested urban environment at ground level. Initial consultations with the various relevant District Councils have received support to study the potential of developing urban underground space.

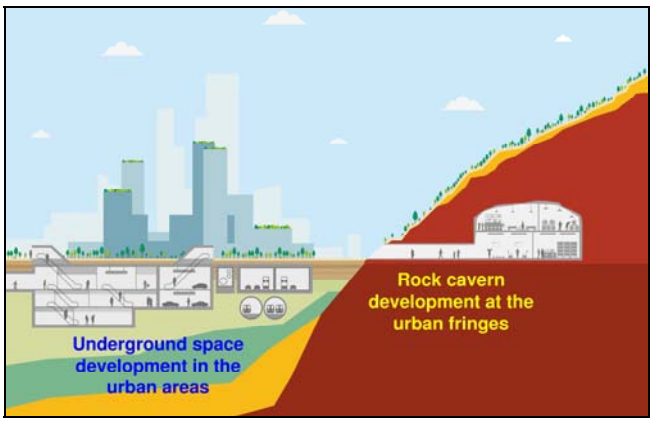

Figure 7 Relative Urban Setting for Rock Cavern and Underground Space Development

8.1 Territory-wide Study on Underground Space Development in the Urban Areas

The prime objective of the Territory-wide Study is to explore the opportunities of and constraints on implementing underground space development in the urban areas and new towns of Hong Kong with a view to enhancing the use of urban underground space resources in a systematic and holistic manner. This Territory-wide Study, which commenced in December 2013 for completion by December 2015, is aimed at establishing a comprehensive and objective methodology for developing urban underground space.

The scope of the Territory-wide Study comprises:

(a) Review of local and overseas examples to identify suitable measures and implementation strategies to facilitate underground space development in Hong Kong.
(b) Identifying broadly areas with clear potential for underground space development in the urban areas and new towns of Hong Kong to establish territory-wide opportunities.
(c) Development of conceptual schemes to demonstrate opportunities for space creation and connectivity enhancement for selected areas, and highlight any possible constraints/issues in implementation.
(d) Review of specific topics related to underground space development: including the prospect of infrastructure reorganization, harbour-crossing pedestrian-cum-retail link development, and formulating guidelines for developing underground space in new developments.
(e) Consultation with relevant stakeholders.

8.2 Pilot Study on Underground Space Development in Selected Strategic Urban Areas

Complimentary to the Territory-wide Study and as a step to further expedite underground space development, four strategic urban areas, viz Tsim Sha Tsui West, Causeway Bay, Happy Valley and Admiralty/Wan Chai, have been selected for a pilot study to identify suitable priority projects for early implementation. These areas are densely developed nodes for commercial, entertainment and tourism purposes. However, the complex urban setting and the limited land resources in these areas are imposing constraints on improving the built environment and hindering further development. On the other hand, these areas are of high development potential, as they are mostly covered by existing and/or planned MTR networks and serve as transportation hubs to the nearby areas.

The prime objective of the Pilot Study is to enhance the use of underground space resources more systematically by creating space for commercial and other uses and enhancing connectivity of facilities in these districts to meet the needs of the community, thereby improving the congested urban environment at ground level. The study is targeted to commence in mid 2015 and will take about 2.5 years.

The scope of the Pilot Study comprises:

(a) Evaluation of overall merits and key issues of underground space development in the four selected strategic urban areas.
(b) Formulation of an Underground Master Plan for each selected area.
(c) Identification of priority projects within each selected areas and preparation of conceptual design schemes for the priority projects.
(d) Establishment of engineering feasibility of the priority projects by carrying out broad planning, technical and financial assessments and preliminary environmental review.
(e) Preparation of preliminary engineering design for each priority project.
(f) Recommendation of the way forward for implementation of priority projects.
(g) Public engagement and consultation with relevant stakeholders.

9. UNDERGROUND DEVELOPMENT AS A LAND SUPPLY OPTION

Hong Kong's planning and engineering professions have continually risen to the challenge of the changing future development needs of Hong Kong. We have the appropriate ground conditions and certainly the required technical skill sets, as demonstrated by the wealth of underground development in Hong Kong. However, systematic consideration of developing rock caverns at the urban fringes and underground space in the urban areas will require a change in mindset, not only by the Government but for all stakeholders. It will require the willingness to evaluate and embrace the latest technologies so as to reduce the facility footprint whilst maintaining and ideally upgrading and improving the existing services.

Ling (2011) states that 'we should have a strategic vision to enhance a more effective use of underground space and make underground space development as an integral part of the city structure for the benefit of sustainable development of Hong Kong. A multi-disciplinary approach guided by a clear public policy to promote underground development and a set of administrative guidelines to deal with the technical and institutional issues is necessary to make such a vision come true'.

We need to create an environment in which the option of cavern and underground space development is not overlooked or treated as unconventional. The planning and execution of underground development need to become part of the mainstream development process to not only help create new land resources but also provide the optimal living environment for Hong Kong. Rock caverns and urban underground space should become a part of Hong Kong's sustainable planning and development strategy, and an integral part of Hong Kong's enhancing land supply strategy.

10. CONCLUSIONS

In 2011, the study on "Enhanced Use of Underground Space in Hong Kong" concluded that the geology and topographical setting of Hong Kong were very favourable for cavern development. Members of the public are generally supportive of the rock cavern initiative as part of Hong Kong's pursuit of sustainable development.

By reprovisioning suitable Government facilities inside caverns and releasing the occupied land as well as any adjacent sterilized land for housing and other uses, cavern development is a viable option to expand land resources. Cavern development could also be a good source of land supply for accommodating new Government and public sector facilities which will otherwise occupy surface land. Reserving underground space could accommodate future projects and expansion of existing underground facilities. For those nuisance or potentially hazardous facilities, the cavern option may help to reduce adverse impacts on the local environment, remove incompatible land uses and alleviate the NIMBY sentiment.

Some 50 strategic cavern areas, covering a total plan area of 50 km^2, have been delineated at the urban fringes for future cavern development. Given the potential for multi-layer cavern development, a substantially greater usable area could be created in underground space.

The study on "Long-term Strategy for Cavern Development", which commenced in September 2012 for completion by late 2015, will formulate policy guidelines to facilitate cavern development for both private and public sectors. By adopting a holistic approach in planning and implementation, this should allow rock cavern development to become a sustainable means for enhancing land supply.

Apart from rock caverns, urban underground space is also a viable source of long-term land supply. Hong Kong has a wealth of such "hidden land" that can provide almost "unlimited" space for future development. We should treasure this precious asset and exploit it in a coordinated and proficient manner in order to sustain the growth of our city. Let us team up together to work diligently for a better future for Hong Kong.

11. ACKNOWLEDGEMENTS

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