RE-PROVISION OF WATERWORKS FACILITIES OF WATER SUPPLIES DEPARTMENT FOR PROPOSED CENTENNIAL CAMPUS OF THE UNIVERSITY OF HONG KONG

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Abstract: *The University of Hong Kong (HKU) have proposed the development of a Centennial Campus at a site to the west of the Main Campus to celebrate its centenary in 2011 and to prepare for the implementation of the four-year undergraduate degree curriculum in 2012. In December 2005, Black & Veatch Hong Kong Limited (B&V) was commissioned by HKU to provide engineering consulting services for the infrastructure of the proposed HKU Centennial Campus. As the site for the proposed development was occupied by the then existing fresh water and salt water service reservoirs and associated waterworks facilities managed by the Water Supplies Department (WSD) of the Government of the Hong Kong Special Administrative Region (HKSAR), it required the re-provisioning of these waterworks facilities and associated infrastructure works prior to the development of facilities for the Centennial Campus. This paper will present the background to the Project, the various factors that were considered in developing this innovative, sustainable, and environmentally friendly cavern solution and a description of the work carried out by all the parties involved -HKU, WSD, B&V, and Gammon Construction Limited (GCL).*

1. INTRODUCTION

The University of Hong Kong (HKU) develops its new campus in response to a major landmark in the education history of Hong Kong: the new academic structure for senior secondary and higher education known as the “3+3+4” reform. The new curriculum provides a four-year undergraduate programme offering a broad and flexible learning experience to students. To achieve this goal, HKU must expand and acquire space to cater for the additional undergraduate intake. The intake of the first cohort of the new curriculum undergraduates will take place in 2012, a time to also celebrate the centennial of HKU. The new campus: the Centennial Campus, must be completed in time to fulfill its mission. The Re-provision of Waterworks Facilities thus plays a critical role in providing the infrastructure solution towards the success of a new HKU campus.

To realize the vision of a “University District”, HKU established four important guiding principles to be closely observed and followed in the process of designing and implementing the infrastructure works and in the development of its new campus.

The Learning Community: The ever-changing University landscape must support the intellectual curiosity, social well-being and spiritual life of all its residents and visitors

The Environment and Heritage: The University cherishes its unique natural environment and seeks a sustainable community that respects its history, culture and natural setting.

A Unified Campus: Each physical change to the University estates – building, open space, neighbourhood – should enrich and harmonise with the whole community.

An Open and Respected Process: As an integral part of Hong Kong, the University invites all who have an interest in its future to share their views.

Given HKU is situated in the vastly developed area of the Central & Western District where availability of suitable land for developing its new campus is scarce, the site selection stage of the project already posed a big challenge for the University. Following a feasibility study, HKU identified that the area to the west of its Main Campus was the most suitable location for its expansion. The proposed area was zoned Government, Institution or Community (GIC) where Education Institution was always permitted. The new campus location also provides essential linkages to the existing Main Campus on the eastern side, the University student villages located along Pok Fu Lam Road and also the future public transport node provided by the Mass Transit Railway (MTR) station at the front door of HKU.

As the site was occupied by the then existing fresh water and salt water service reservoirs and associated waterworks facilities managed by the Water Supplies Department (WSD), it required the re-provisioning of these facilities and associated infrastructure prior to the development of facilities for the Centennial Campus. Following a thorough discussion among HKU and WSD, WSD finally agreed to the proposal to extend the HKU’s campus into the WSD’s premises on the conditions that the waterworks facilities would be re-provided in the same site and that the existing water supplying systems would be maintained during the re-provisioning works.

The challenge in project planning did not end when an appropriate location was selected. HKU was conscious of the constraints posed by the site whilst constantly aware of the planning principles laid down in guiding its development. As an education institution which pioneers in the promotion of environmental friendliness and sustainability, HKU in collaboration with WSD demanded a solution that respects the existing environment, causing as little damage to the trees and ecology of the site on the one hand, and minimising disturbance to nearby residents and the university public on the other as well as meeting the functional need of the waterworks facilities in provision of water supply to the public. The solution must also respect the cultural heritage of the site signified by the presence of the historic buildings and their past histories. HKU together with WSD laid down these important principles and called for an innovative, sustainable and people respected solution to fulfil the high standards set for itself. An aerial photograph showing the location of the proposed HKU Centennial Campus is shown in Figure 1.

Figure 1 Proposed Centennial Campus of the University of Hong Kong
(Source: HKU Centennial Campus website (http://www.hku.hk/cecampus/))

The following describes the project background and, the various factors that were considered in developing this innovative, sustainable, and environmentally friendly cavern solution and a description of the work carried out by all the parties involved -HKU, WSD, B&V, and GCL.

1.1 PREVIOUS SCHEMES

During the Preliminary Project Feasibility Study (PPFS) stage between 2003 and 2005, HKU's PPFS consultant considered various options for the re-provisioning of waterworks facilities and the subsequent development of campus facilities. The options considered comprised of the construction of a decking structure covering the existing or re-provided waterworks facilities with future campus development above the decking structure, the re-provision of the service reservoirs on the existing slopes along Pokfulam Road, and an open-cut site formation option within the Lung Fu Shan hillside to provide land for the construction of replacement fresh water service reservoirs.

Amongst the abovementioned options, the open-cut site formation option was selected as the preferred option by the PPFS consultant. The recommended option comprises the construction of replacement fresh water service reservoirs on the slopes at the southern portion of the site adjacent to the existing salt water service reservoirs. This option involves massive cutting of slopes and felling of a significant number of trees to provide space for the construction of the service reservoirs.

1.2 PROPOSED ALTERNATIVE SCHEME

HKU have adopted sustainability as one of the guiding principles for the Centennial Campus development. After the engagement of B&V as the engineering consultant for the infrastructure of the proposed Centennial Campus in December 2005, B&V performed a thorough review of the proposed scheme for the re-provisioning of the waterworks facilities. The review by B&V considered the comments raised by various Government Departments in previous stages of the proposed development, and the increasing awareness and expectations of the community and HKU regarding the incorporation of the concept of sustainability in new developments.

Prompted by WSD's initiative of building a service reservoir inside a cavern, B&V proposed an innovative, sustainable, and environmentally friendly solution involving the re-provisioning of the salt water service reservoirs inside a cavern to be formed inside Lung Fu Shan hillside. The placing of a service reservoir in a cavern is unprecedented in Hong Kong. This is well in accordance with the four principles for urban development that WSD pays high regard to, namely conserving natural environment; optimizing land use; minimizing environmental impacts and preserving historic water infrastructures.

On top of the benefits of the cavern scheme in avoiding massive excavations and extensive tree felling, the proposal facilitates the preservation of the historic buildings of WSD within the site. It was decided at an early stage of the Project to conserve the Western Senior Staff Quarters (Grade II Historic Building) and the Western Staff Quarters (Grade III Historic Building) located at the northern portion of the site. However, the Elliot Treatment Works (Grade III Historic Building), which is located at the heart of the site, was a particular challenge to conserve due to the presence of many physical and technical constraints. The Project team comprising members from various organisations worked very hard to eventually develop a feasible option with WSD to retain this remaining historic building, in support of HKU's strong commitment to heritage preservation.

The proposed cavern scheme also achieves significant time and cost savings. The duration of construction of the alternative cavern scheme for the re-provisioning of waterworks facilities is about 30 months, which is about 6 months shorter than the initial open-cut site formation scheme. Moreover, the proposed cavern scheme provides significant saving on the initial construction cost. In addition, the recurrent costs for this alternative cavern scheme are comparable to those of the existing waterworks facilities.

2. THE CONTRACT

The completion of the new campus for a student intake in 2012 meant that HKU would have less than 7 years to bring the Centennial Campus from scratch to fruition. In anticipation of the need for an innovative engineering solution for the re-provisioning works and foreseeing the criticality in the timely completion of the works, HKU decided to adopt a Design and Build procurement approach over the more traditional engineering design approach. By doing so, HKU wished to shorten the time spent on the drawing board under the traditional approach, whilst on the other hand aimed at creating an early amalgamation of a partnering team comprising of HKU, WSD, the engineering consultant and the contractor to tackle and resolve the technical difficulties through collective knowledge and expertise.

The client of the Contract is HKU with WSD being the owner and operator of the existing and future waterworks facilities. B&V was appointed to be the Supervising Officer (SO) of this Project and also provided a team of Resident Site Staff (RSS) to administer the Contract and supervise the Works on site. GCL was selected to be the Contractor of the Works in March 2007 through a tender process. The Contract Sum of the Contract was HK$500 million. A general layout plan showing the proposed Works are attached in Figure 2.

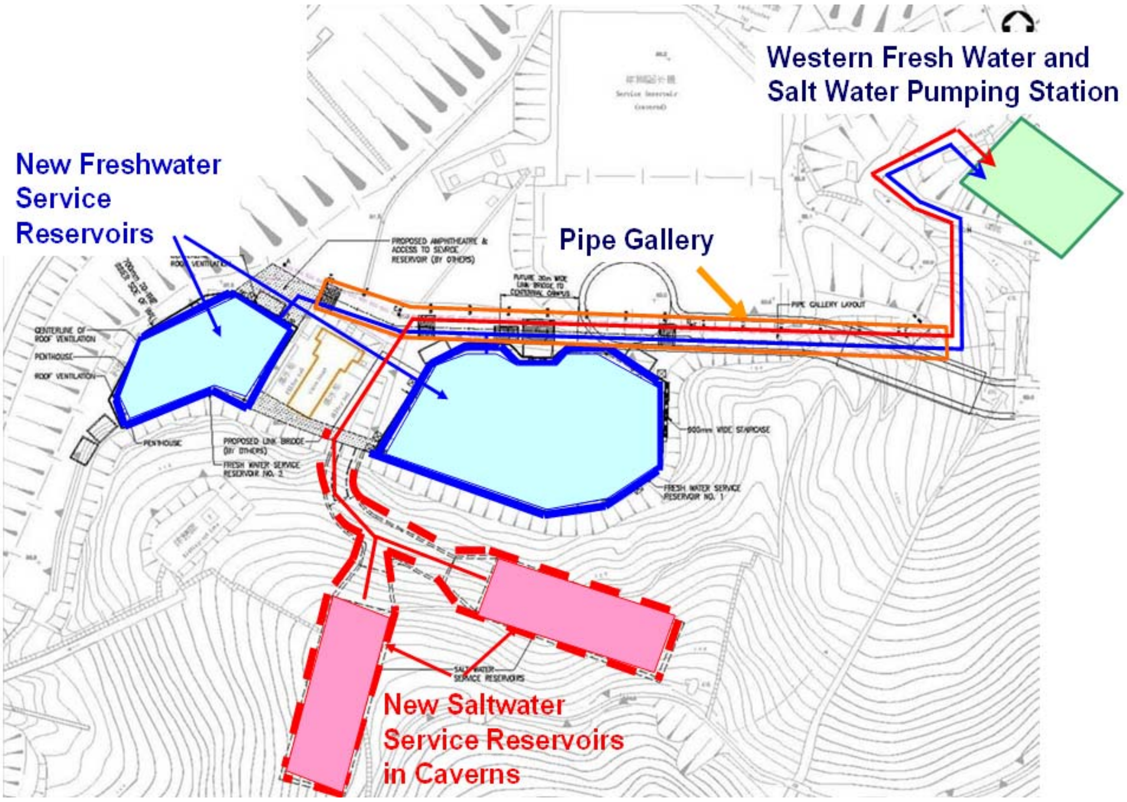

Figure 2 A general layout plan showing scheme for the re-provision of waterworks facilities

The scope of Works involved the design, construction and commissioning of the following elements:-

(i) Two fresh water service reservoirs with a total capacity of 26,500m^3;
(ii) Two salt water service reservoirs with a total capacity of 12,000m^3 to be located in two rock caverns;
(iii) Construction of pipe gallery housing future WSD utilities;
(iv) All necessary waterworks pipe networks and facilities for the proper operation of the proposed service reservoirs;
(v) Vehicular access connecting the proposed Centennial Campus and the existing university campus;
(vi) Slope upgrading works for all existing and proposed man-made geotechnical features, natural terrain hazard study and natural terrain hazard mitigation measures affecting the Works area;
(vii) Temporary watermain diversions and saltwater supply systems to maintain the water supply during the period of construction; and
(viii) Protection measures to all operating waterworks facilities and historic buildings.

3. SUSTAINABILITY AND ENVIRONMENTAL CONSERVATION INITIATIVES

By housing the replacement salt water service reservoirs in caverns, substantial slope cutting would be avoided through elimination of extensive site formation works for the salt water service reservoirs, which in turn minimises modifications to the existing landform. The proposed cavern scheme eliminates the loss of about 6,000 m2, i.e. 0.6 hectare, of secondary woodland at the southern portion of the site.

Considerations leading to the formulation of the proposed cavern scheme include the following:
(1) Minimise environmental impact by avoiding modification of existing landform;
(2) Minimise ecological impact by the avoidance of substantial tree felling and the preservation of woodland habitat of the natural hillside;
(3) Minimise visual impact;
(4) Minimise heritage impact by preserving historic buildings in-situ; and
(5) Minimise other environmental impacts such as reduction of dust and noise impact during the course of the construction.

4. CONSIDERATIONS FOR PLANNING AND PROGRAMMING OF THE WORKS

The planning of the Project required close cooperation and communication between HKU, WSD, B&V and GCL to ensure that the various technical challenges of the Project could be met, including current and future interfaces between HKU and WSD, whilst ensuring that the waterworks facilities remained operational throughout construction. A comprehensive planning schedule and clear lines of communication between the parties were established. Examples of the success of this approach were evident from the sequencing of the works, and in particular the decommissioning of the Western Salt Water Service Reservoir, and the planning of watermains diversions.

Several temporary and permanent watermains diversions were carried out in order to facilitate the construction and connections to the existing watermain system after completion of the new service reservoirs. All of the parties worked closely together to ensure that the design of any permanent or temporary waterworks considered the need to minimise any temporary suspension of water supplies as far as possible. Regular liaison meetings amongst WSD, B&V and GCL were conducted to discuss the working procedures and arrangements for any period of suspension of water supplies. The frequency of temporary water supplies suspension was established to not exceed once per month and maximum eight hours per occurrence. The impact on the fresh water supply to the public was reduced to an insignificant level except to some isolated spots.

The Elliot No.1 Salt Water Service Reservoir (SWSR) was on the critical path of the construction programme as this facility needed to be demolished to create space for the construction of the Fresh Water Service Reservoirs (FWSR). However, the existing SWSR could only be taken out of service when one of the new service reservoirs inside the tunnel was completed and put into operation. As the new SWSRs within the caverns were themselves critical in the construction programme, an alternative scheme was required to minimise any potential delay to the completion of the Project. After detailed investigation of possible solutions, a proposal was developed to provide a temporary salt water tank on site and adjust the rating of the existing pumps. This proposal allowed for early decommissioning of the Elliot No. 1 SWSR and consequently an earlier start to the FWSR construction.

The design of the new facilities were carefully considered to eliminate interfaces between HKU and WSD. For example, the pipe gallery was designed to allow WSD staff to inspect the watermains and carry out maintenance works inside the pipe gallery without disturbances to HKU.

5. DESIGN CONSIDERATIONS

The design of the service reservoirs and associated facilities were carefully considered to facilitate the development of the Centennial Campus, which is to be built on the existing platform occupied by WSD waterworks facilities. Other than the re-location and re-provisioning of the waterworks facilities to cater for the development, the design of the new facilities was developed with special considerations for interfacing with the Centennial Campus development, including allowing for the additional loadings during the campus construction.

5.1 Pipe Gallery

The pipe gallery is used to house the incoming and outgoing pipes for both proposed fresh water and salt water service reservoirs. Lifting facilities and lighting provisions are provided inside the gallery to facilitate routine inspection and maintenance by WSD in the future. Moreover, the pipe gallery acts as a drainage channel to effectively drain away large quantity of water in the rare case of burst mains in tunnel and in the pipe gallery. The typical section of pipe gallery is shown in Figure 3.

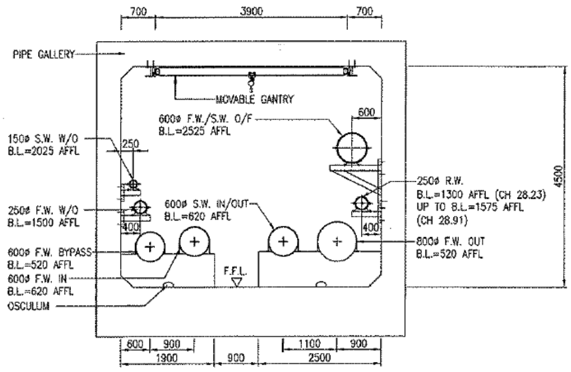

Figure 3 Typical Sections and Pipeline Arrangement in Pipe Gallery

The following are the major design criteria that have been taken into account in the pipe gallery design:

- Optimise the interior space to facilitate the maintenance works;
- Organise the pipelines to an arrangement that every part of the pipes are easily reachable;
- Pressurised pipes are installed at a low level for the ease of inspection and maintenance;
- Provision of hoisting facilities for material transportation;
- A 900mm wide walking corridor is provided. The corridor enables use of a trolley for transporting light duty materials;
- Provision of lighting, cable tray for signaling / communication equipment

5.2 Fresh Water Service Reservoirs (FWSRs)

The FWSRs are monolithic structures with no movement or expansion joints. The entire structure is founded on existing ground or mass concrete. This minimises the chance of leakage through joints, results in savings in long term maintenance, and savings by reducing the amount of water loss through leakage. The base slab of the FWSR is designed as a flat slab on firm to medium dense ground or mass concrete. The existing founding material underneath the northern edge and western edge of FWSR No.1 is strengthened by mass concrete replacement (over 2.5m thick in general) to cater for the potential loadings during the HKU Centennial Campus Site Formation Works during 2009 to 2011.

The control of leakage and crack width are critical factors for the performance of the water retaining structures. Therefore, crack width checks were performed for both direct tension in immature concrete due to possible restrained thermal and shrinkage movement, and flexural tension in mature concrete. Moreover, GCL introduced the Injecto Sealing System for post-injection of construction joints, as a second line protection of leakage in conjunction with the provision of PVC waterstop. Injecto is a preventative measure for the permanent sealing of construction joints. Injection grout is injected to protrude out of the concrete at easily accessible places so that the leakage joints can be permanently sealed.

5.3 Salt Water Service Reservoir Tunnel

5.3.1 Outline of the Salt Water Service Reservoir Tunnel

The twin cell service reservoir tunnel was constructed at Lung Fu Shan. The tunnel portal is situated at the northern open cut slope of Lung Fu Shan. The portal is strategically located between the existing historic filter building, which has been retained, and one of the proposed fresh water service reservoirs. The location strikes a balance between future operation and maintenance of the waterworks facilities, effective land use, and the ground conditions of the tunnel site.

Starting from the tunnel portal, an access tunnel with an overall span of 8.6m and height of 8m is excavated into Lung Fu Shan at a level of about +85mPD. The access tunnel is about 40m in length running parallel to the existing open cut slope in a southeast direction after excavation southwestward into the hillside for about 10m. The access tunnel is directed towards one of the 17.6m span caverns 50m in length via an enlargement transition zone of 10m in length. A branch tunnel divides from the access tunnel at about 28m from the portal and drives towards the southwest with the same dimensions of the enlargement transition zone and main tunnel. At the enlargement transition zone, the tunnel progressively increases in height from 8m to 17m and in span from 9.6m to 17.6m.

5.3.2 Excavation Process and Temporary Support Works

The Salt Water Service Reservoir Tunnel was entirely excavated by mechanical methods using hydraulic breakers and splitters. Non-explosive expanding agent was also used in some occasions to overcome very strong rock. This construction method is considered to be the most suitable method in terms of environmental, geological and time considerations for this particular site. In the initial 20m of the access tunnel, the sound rock cover thickness was less than half the span of the access tunnel (i.e. the low rock cover condition). As such, initial tunnel support including pipe roof canopy was installed prior to the excavation. A steel arch with fibre reinforced shotcrete was subsequently installed after each excavation round as temporary support. Probing at the tunnel roof was carried out to investigate the ground condition ahead and to check the extent of the sound rock cover. After the first 20m, the rock cover became adequate and temporary supports, including patterned rock bolt and fibre reinforced shotcrete, were employed. The temporary support measures required were determined based on the rock mass classification as assessed on site in accordance with the Q-system (Barton, 1993).

Due to the increase in tunnel roof level at the enlargement transition zone from the divided access tunnels to the reservoir tunnels, problem of potential low rock cover was again a major challenge for the excavation works. Probing, additional boreholes and field mapping were carried out to identify the geological structures for the development of suitable temporary support works. A heading and benching approach with the construction of the permanent tunnel arch roof lining prior to the bench excavation was adopted in order to facilitate the construction sequence and to enhance the stability of the tunnel roof for the later bench excavation.

Other considerations such as groundwater inflow, ground movement due to low rock cover and near surface conditions were closely monitored and addressed by various measures such as convergence monitoring, ground settlement monitoring and groundwater monitoring.

Thorough planning of the construction sequence, careful investigation of the existing ground conditions and proactive design and construction review were considered as the essential elements for the safe and on-time excavation for the two large reservoir tunnels.

5.3.3 Permanent Works for Access Tunnel and Enlargement Transitions

To suit the ground conditions and to avoid excessive groundwater drawdown due to the tunnel works, the first 15m of the access tunnel were designed as an undrained tunnel, with the remaining portion designed as a drained tunnel. The finished internal width and height of the access tunnel are both 7.2m. The principles of the design and construction of the enlargement transitions are similar to those for the drained access tunnel.

The undrained portion of the tunnel was designed to withstand full hydrostatic pressure and was surrounded by waterproofing membrane. The permanent lining was constructed using traditional reinforced concrete methods excluding the upper circular arch roof. The arch roof for the access tunnel was constructed using steel fibre reinforced shotcrete with plain shotcrete as the smoothing layer after completion of the lower portion of the permanent lining.

The drained portion of the tunnel was designed with a groundwater relief system. 50mm diameter, 1m long drain holes were drilled and proprietary drainage strips were installed to facilitate groundwater drainage. A drainage composite was also installed with the drainage strip to further enhance drainage performance. The groundwater drained into a perforated drainage pipe surrounded by a drainage layer below tunnel invert. Other than the incorporation of the groundwater drainage system, the construction of the permanent lining for the drained tunnel was similar to the undrained tunnel.

Moreover, the ventilation ducts are located at lower level to facilitate the extraction of any possible chlorine gas, which is heavier than air, released from the salt water. The mains are purposely laid on the two sides of the access roads to facilitate future inspection and maintenance. Typical arrangement of access tunnel is shown in Figure 4.

5.3.4 Salt Water Service Reservoir Structure

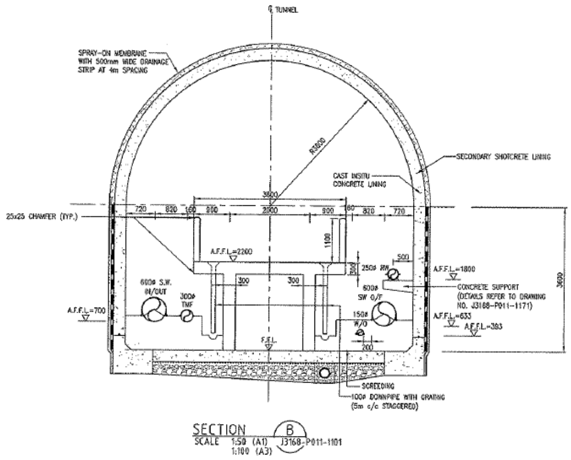

Figure 4 Typical arrangement of Access Tunnel

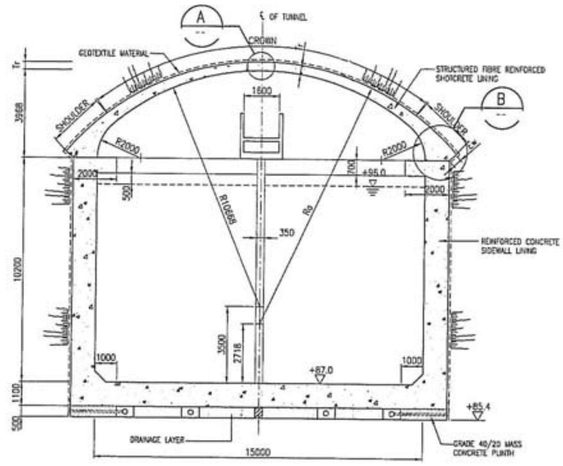

Figure 5 Salt Water Service Reservoir in Cavern

The two salt water service reservoirs were housed within the large span rock caverns. The service reservoir structures were designed to serve as water retaining structures and to act as the tunnel permanent linings. Waterproofing layers are also laid on the external face to avoid ingress of water into the SWSRs to prevent any possible contamination of water. The service reservoir structures are monolithic reinforced concrete structures. The arch roof above the service reservoir structure comprises a steel fibre reinforced shotcrete lining with a plain shotcrete smoothing layer, in which the shotcrete arch roof was constructed at the time of tunnel header excavation, resting on an elephant foot in sound rock before full completion of the tunnel permanent lining. The permanent lining was designed for the drained case with groundwater relief system incorporated. A typical section of the salt water service reservoir cavern is shown in Figure 5.

5.4 Tunnel Ventilation

The ventilation system adopted for the salt water tunnel is a simple “pull system”. Two fans are installed at the top of the tunnel portal house; each extracting air from the tunnel. Fresh air is then forced into the tunnel due to the difference in air pressure. A concrete air vent is constructed underneath the whole access road to the front wall of the salt water service reservoirs and another vertical concrete shaft is then connected to the air vent above the salt water service reservoirs.

Exhaust air louvers are provided at both sides of the air vent walls underneath the access road and the pedestrian walkway above the salt water service reservoir allowing the air to be extracted out of the salt water tunnel.

5.5 Emergency Vehicular Access (EVA) Retaining Structure

5.5.1 Outline of the Emergency Vehicular Access

The re-provisioning of the waterworks facilities involves the construction of an access road connecting the existing HKU Main Campus and the site. The EVA will serve as both a vehicular and pedestrian link between the proposed Centennial Campus and the Main Campus. It also serves as the maintenance access for the re-provided waterworks facilities.

The EVA is a dual lane carriageway, 7.3 m wide with 1.6 m wide footpaths on either side. The EVA comprises a short section of viaduct at the eastern end with the remaining portion as an on-grade carriageway. Due to the limited space of the site, it was anticipated in the planning stage of the Project that part of the EVA will encroach into existing slopes. Intensive design input was provided throughout the Project; with an objective to achieve a technically feasible solution which minimises tree removal, substantial modification of existing landform and long term visual impact. The design team considered different alternatives starting from different EVA alignment options, different construction methods including road formation by traditional open cut site formation, mined tunnel, cut and cover tunnel, and construction of a vertical retaining structure.

As a result of the design development process, a scheme involving the construction of a vertical retaining structure with a carefully selected road alignment was adopted. This option preserves most of the existing trees, but calls for the need for a substantial retaining structure to support the existing hillside. Landscaping works on the retaining structure were proposed to minimise visual impact. Moreover, due to limited space available on site and the existing Western Fresh Water and Salt Water Pumping Station being located at low level, deep water mains connecting the re-provided waterworks facilities and the pumping station are required to be placed along the access road in front of the retaining structure. The requirement to retain the steep existing hillside and to accommodate deep water mains lead to the need for the construction of an excavation and lateral support (ELS) system with a maximum overall excavation depth of almost 30m. Various temporary and permanent support options were reviewed in the planning, investigation and design stages to ensure the selection of a technically feasible solution that best suits the heavily constrained site conditions.

5.5.2 Temporary Excavation and Lateral Support Works

The ELS system adopted comprises the construction of vertical elements in the form of 273mm diameter pipe piles with king posts socketted into the bedrock. Temporary tie-backs in the form of 50mm diameter steel soil nails were designed to enhance lateral resistance for the upper portion of the ELS system above the existing ground level. For the lower portion below existing ground, a typical ELS system with steel walings and struts was adopted to facilitate the excavation. One of the major challenges for the excavation works is that the excavation is required to be carried out only a few metres away from the 80 year old Western Fresh Water Service Reservoir, which is still in operation. This constraint leads to stringent requirements to minimise the stress change and deformation of the existing service reservoir structure. Various monitoring requirements were also incorporated to monitor the performance of the ELS system and to detect any adverse impacts to the existing service reservoir. Moreover, a heavy duty temporary steel working platform was also constructed for the implementation of the works in order to avoid any adverse impacts on the service reservoir, to maintain vehicular access to the site and to allow concurrent work fronts through this area to expedite progress of the Works.

5.5.3 Permanent Retaining Structure

The permanent retaining structure comprises the construction of an L-shaped reinforced concrete retaining structure, with the base of the retaining structure on the passive side. In addition to the substantial retaining height required due to the site location, the permanent works design is also required to cater for the future basement excavation for construction of the Centennial Campus, which is to be carried out in front of the retaining structure. Inclined 273mm diameter mini-piles with four 50mm diameter steel bars socketted into the bedrock without pre-stressing were designed to act as permanent tie-backs for the retaining structure. The inclination of the mini-piles range from 20 degrees to 55 degrees to suit the site conditions and the geotechnical design. The construction sequence of the mini-piles was also incorporated into the planning and construction of the excavation and lateral support works. A section of the EVA Retaining Wall and Pipe gallery is shown in Figure 6.

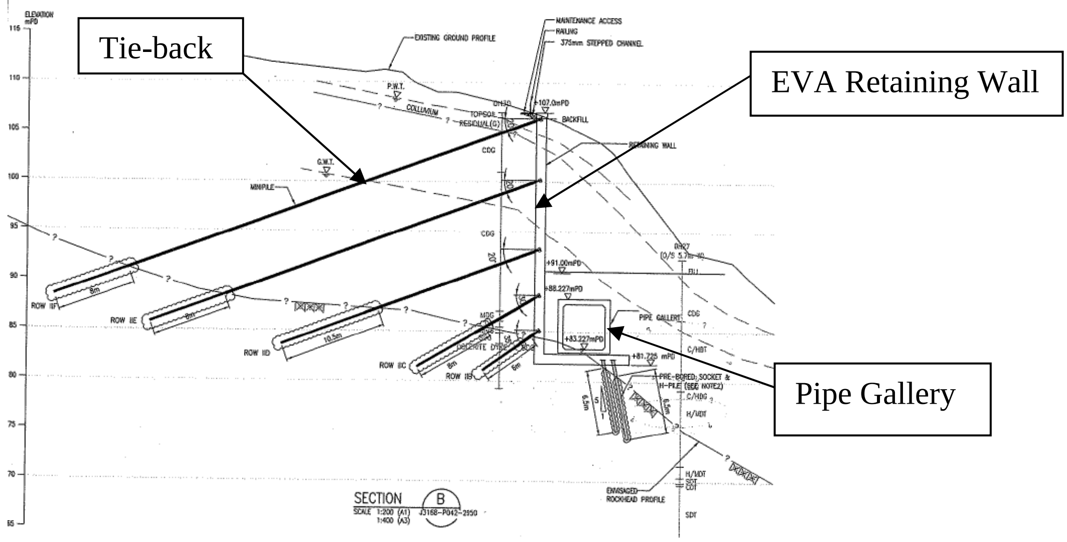

Figure 6 Section of EVA Retaining Wall and Pipe Gallery

The retaining structure was designed to found on sound rock or on pre-bored H-piles in 406mm diameter pre-bored holes. The permanent mini-pile tie-backs and pre-bored H-pile foundation provided strong lateral resistance to the high retaining structure, limiting permanent deformation of the retaining structure and the adjoining ground. This is particularly important as the water supply pipeworks were housed inside the pipe gallery sitting at the base of the retaining structure. This heavily restrained retaining structure limits deformation and long term movements, thereby minimising any undesirable effect on the pipe works inside the pipe gallery. The engineering design also provides for the subsequent incorporation of state-of-the-art landscaping works designed by the Centennial Campus project architect, to ensure that the retaining wall will blend in with the adjoining natural hillside and the future Centennial Campus.

6. CONCLUSION

The Re-provision of Waterworks Facilities was a demonstration of a successful integration of a partnering team comprising of HKU, WSD, B&V and Gammon. The team provided an innovative solution to an engineering-challenged task, while maintaining the high standards guided by the Four Planning Principles of HKU. The timely completion of the re-provisioning works provided HKU with the essential site for constructing its new campus as scheduled. The completion of the re-provisioned service reservoirs meant that WSD and the public could now enjoy the benefits of the enhanced waterworks facilities. The preservation and future reuse of the historic buildings enabled their waterworks histories be continued and passed onto future generations. The ecology of the site was unaffected whilst additional greening was provided to enhance the scene of the natural surroundings. The result of this project was therefore not just a Win-Win solution to any two parties, but an All-Win solution to all.

The success of this Project stemmed from the good partnering amongst all the parties involved. The well structured and effective partnering process helped establish the firm commitments to cooperation and shared goals within the Project team which made this extraordinary Project become a reality.

It is also believed that the successful use of the cavern scheme sets an example for the further sustainable development of similar sites to the HKU Centennial Campus, thus maximising the potential use of valuable land resources without jeopardising our natural resources and environment.

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