Design Strategies for Sustainability and Integration of Water Treatment Works – Case Study of Sha Tin Water Treatment Works, Hong Kong

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ABSTRACT

Hong Kong as an international finance centre is a fast-paced and high density community, where the development of sustainable built environments faces numerous challenges. In-situ reprovisioning of Sha Tin Water Treatment Works – South Works is an example demonstrating how the built environment of the water treatment works is enhanced despite the challenges.

Sha Tin Water Treatment Works, comprising the South Works and North Works, is the largest treatment works in Hong Kong meeting about 30% of the total fresh water demand in the territory. The South Works was commissioned in 1964 with a treatment capacity of 364,000 m3 per day while the North Works was commissioned in stages since 1973 increasing the treatment capacity to 1,227,000 m3 per day. Due to the aging of plant and equipment which are approaching the end of their service life, the South Works requires major renovation and replacement to meet the growing demand.

Achieving sustainable reprovisioning of the South Works, building solutions including but not limited to onsite green building planning and massing, hydro power generator, ice storage system and Thermal Vision Based Security Surveillance (TVBSS) system enhancing energy saving and minimizing light pollution to neighbourhoods, etc. which have been considered in the design, will be discussed in this paper.

Keywords: *sustainable development, green building, energy efficient*

1. INTRODUCTION

Sha Tin Water Treatment Works (STWTW) is the largest water treatment works in the Government of the Hong Kong Special Administrative Region (HKSAR). It was commissioned in 1964 with three subsequent expansions bringing the total nominal treatment capacity to 1,227,000 m³/day. The 52 years old plant and equipment in the South Works are approaching the end of their service life and require major renovation and replacement.

The challenge is to complete the in-situ reprovisioning of the South Works together with major common facilities for both the South Works and North Works within the site, which is already fully utilised. It is also necessary to maintain continuous operation, maintenance and security of the North Works during the South Works upgrading.

In the last 50 years, economic development was the driving force globally to create a better world. 50 years on, the focus has shifted to sustainable development, ensuring that our descendants can enjoy a continuous growth in a healthy manner.

As the design of overall site layout is dictated by water treatment process train, modern treatment technologies were incorporated to enhance site utilisation and resolve the congested site condition. Apart from providing the state-of-the-art treatment technology, the project also aimed at developing an integrated building design which respects the existing surrounding landscape environment and its adjacent land users. The paper will be focused on the sustainable building development and energy efficient design.

2. BUILDING PLANNING AND MASSING

STWTW is located in a natural valley surrounded by two major country parks, namely, Lion Rock Country Park to the South and Kam Shan Country Park to the west. Although there are no direct pedestrian connections to these parks with STWTW, the design layout of buildings is to ensure a coherent green environment that responds to its surrounding open space.

Figure 1: Layout Plan of STWTW with Reprovisioned Administration Building and South Works Treatment Process Precinct

Buildings to be reprovisioned in the STWTW are strategically subdivided into two realm, i.e. Administration Building (See Figure 1 area highlighted in purple) and the water treatment process precinct of South Works (See Figure 1 area highlighted in orange). Each individual realm is characterized by its unique site features.

2.1. Administration building

The administration building encompasses new laboratory space, administration offices, control room for plant operations and training facilities. Sustainability and performance are primary motivators in the design of the building. The design is less about creating a building and more about the concept of tucking the laboratory and control facility into the adjoining hillside to take full advantage of the benefits of a green roof and energy conservation. The shape and form of the building is highly influenced by the unique site characteristics. Horizontal roof surfaces and the terraced building mass allow the building to have a low profile, minimizing the visual impact on the site. It will effectively blend into the hillside.

The building has a modern architectural expression, with glass, metal and stone used throughout the exterior. The design attempts to maximize the amount of day light entering into the building, thereby creating quality workspaces with views that provide the staff with a sense of connection to the outdoors. Sunshades and glass technologies allow this building to perform in a highly efficient manner. The exterior of the building is expressed with clean lines and patterns, with a minimal amount of features.

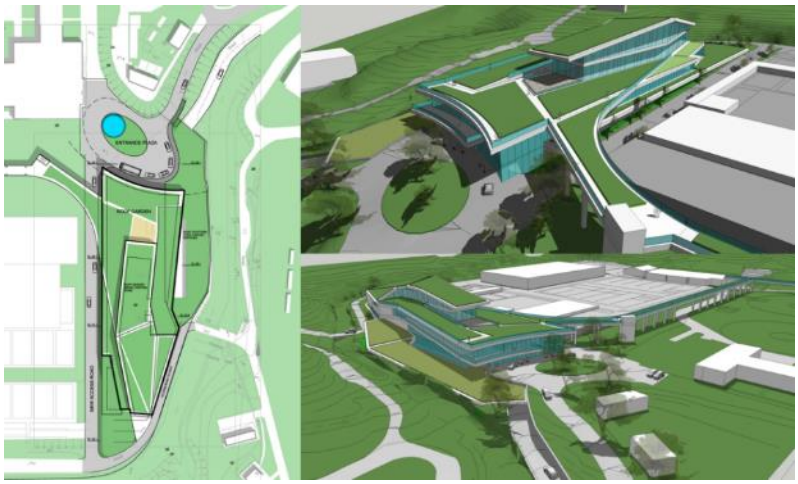

Figure 2: Design of administration building cum Mainland East Laboratory

Key elements of the design are:

- The design of the new building will have a distinct identity.
- The laboratories are designed with standard modules to create consistency and provide flexibility for future reconfiguration.
- The Control Room is located on the third level for clear viewing of the treatment facility.
- Circulation patterns are organized throughout the building to allow visitors to appreciate the various functional components.
- Upper levels are connected by ramps terminating at the Roof Garden and Observation Platform Walkway.
- The roof of the ramps will provide a look-out oriented towards Amah and Lion Rock. The entrance is low and set back to preserve views to Lion Rock.
- Light-filled workspaces are provided for the laboratory and supporting staff.
- The building is integrated into the landscape.

2.2. Treatment process precinct

In line with the administration building, the treatment process precinct of South Works is situated in a large area surrounded by green mountains with a lot of vegetation.

Integrating – The development of buildings aims at creating a complex of different water treatment process units which are designed with simple massing and harmonized with the natural landform. Each building within the process precinct is designed to height fits for its function in order to reduce environmental impact caused by excessive building height. In addition, extensive greenery is provided to the ground, roof and the elevations of the buildings. It helps to blend the buildings with the nature.

Simple – It is aimed at adopting a simple and modern style. The facade of buildings is designed to be precast concrete cladding with fair-faced concrete finish. With the introduction of green features on the elevations and the roof, the monotonic appearance of a linear and long building is dissolved and giving interesting elevations. A different colour is assigned to each individual building. The strong contrast between the light grey wall colour and the colour wall gives a remarkable identity to each of the building.

Figure 3: Design of treatment process precinct

Real Materials – Recycled materials such as structural steel, fair-faced concrete panel, stone, recycled plastic, recycled pavers, environmentally friendly paint etc. are extensively used throughout the treatment plant as far as practicable. The materials proposed are durable, environmentally friendly and less maintenance is required.

Quality of workplace – In the building design, different aspects such as view, capture of daylight, ventilation, spatial arrangement etc. are considered. It is aimed at providing a healthy and comfortable work place for the users of the development.

3. SUSTAINABILITY AND ENERGY

In terms of sustainability, the building design follows the Hong Kong Building Environmental Assessment Method (BEAM) managed by the Hong Kong Green Building Council and BEAM Society.

In the sustainability design, one of the key factors is maximization of natural lighting. In this regard, the solar time throughout the year has been checked and used in the building design. The application of the concept of solar time for passive solar design, and the angular relationship between the sun, the building and any shading devices and obstructing bodies is considered. The degree difference in the altitude of the sun at solar noon between winter and summer combined with local climatic data was used to determine at what time of the year solar gain will be beneficial for thermal comfort in winter, and when it should be blocked with shading in summer.

Rainwater harvesting system is incorporated to form part of the sustainable design. It is simply the collection of rainwater for use that would otherwise go down the drain. An extensive green roof system is implemented on the Administration Building. A water management system with the extensive green roof system can collect rainwater and become a part of the landscape feature. Leaves and other debris would be filtered out before the collected rainwater to be conveyed to a storage tank. The collected rainwater is eventually pumped through distribution system for irrigation purpose.

In the design of the Administration Building, ice storage system is incorporated as an energy management tool that transfers energy use from peak-hours to non-peak hours. As a result, air conditioning can be provided more efficiently, by using lower electricity costs at non-peak time when the energy demand is low at night, to freeze water into ice. The ice is then melt during the day-time to reduce the consumption of electricity at higher costs to meet the air conditioning demands during peak time.

STWTW treats raw water from 5 different sources during the day and throughout the year. Under the existing pumping/transfer pattern, the draw-off from the High Island Reservoir can be at a head of over 25 m when reaching the STWTW. Currently, the excess energy is dissipated by using the Energy Dissipating Chamber. Recognizing the steady draw-off from the High Island Reservoir and the significant potential energy associated with this route, a Hydro Power Plant is proposed to recover the energy from the excessive static head which is now wasted in the energy dissipation chamber.

The design of water turbine generator system for electricity generation is based on the maximum and minimum water power available under different flow and available head. The Hydro Power Plant serves as a base load generating plant to supplement the 380V utility supply at STWTW and is operated for parallel connection with the grid of CLP Power Hong Kong Limited through a unit power converter for automatic synchronization.

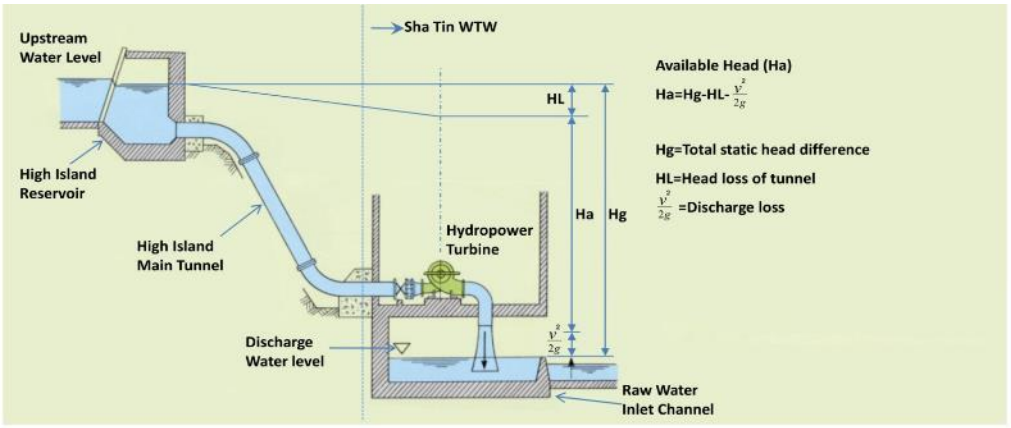

Figure 4: Available head for hydro power plant

4. OUTDOOR LIGHTING AND GREENING

STWTW requires enhanced security measures including outdoor area lighting and security lighting. Security precautions in STWTW is essential in order to prevent theft, unauthorised entry and safeguard premises against vandalism. In the installation, lighting is designed to fulfil two basic functions for (a) outdoor area lighting; and (b) security lighting.

Outdoor area lighting is designed to give a level of illumination appropriate to the use of the area. The lighting should normally be sufficient for normal conditions and if necessary, should be capable of providing an adequate level of illumination at the security fence line when used without the security lighting.

Traditionally, and for those being installed in the present STWTW, fixtures are of High Intensity Discharge (HID) type, either of High Pressure Sodium (HPS) or Metal Halide (MH) lamp. They are always known to have poor energy efficiency, shorter lamp life and poor light level uniformity. Furthermore, they are not considered as Green Power product.

For security lighting, it must be designed to meet the requirements laid down by the Security Bureau of HKSAR. The lights should be strategically located with the required minimum illumination level, using existing buildings whenever possible, but otherwise using poles. The lights should be focused to cover, as far as is practical, the entire security fence line.

However, the excessive light level emitted from the existing STWTW induces light pollution to the residential area in close proximity to the treatment works.

In visiting and reviewing the lighting scheme for open areas at STWTW, due considerations are given to the avoidance of light pollution, over-illumination, but with the minimum level of "lux" or illumination attained to meet safety and security needs on site, particularly at the boundary fence of the works. The approach or principle adopted in engineering the design basis for the lighting scheme in STWTW is "Green Power, Energy Saving, & No Light Pollution".

The context of Light Pollution is not limited to just over-illumination, but also means light intrusion or trespassing, glare disturbances. In other words, it means "suitability" or "appropriateness" of lighting arrangements to meet safety and security needs, but not to cause interferences or disturbances to others.

The application of LED to replace SON floodlight has most of the advantages to be adopted. It is noted that LED in today's lighting market has established its proven ground with good performance, reliability, energy efficiency and easier adaptation. Green and saving energy is achieved by means of using LED, each installation coupled with individual solar panel and wind turbine, and adopting dual mode operating regimes in outdoor area lighting under two open area zones, the essential and idling.

The use of state-of-art thermal network camera complemented with conventional cameras and an intelligent lighting network control system, coupled with Thermal Vision Based Security Surveillance (TVBSS) system as the basic security system is proposed, which is used to further control and dim down lightings in essential open areas and service roads for energy saving and to mitigate the effects of any light pollution caused by public lighting in the works.

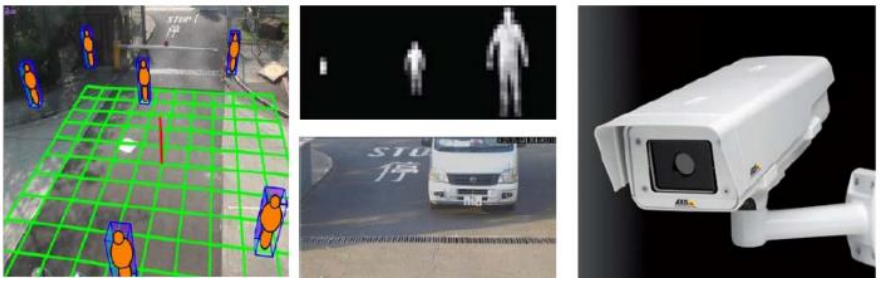

Figure 5: Thermal Vision Based Security Surveillance (TVBSS) system

The cameras of TVBSS system do not capture objects under visible light as for conventional cameras. They detect invisible thermal radiation emitted from the objects, and movement of any objects in the field covered by the camera, regardless of darkness, brightness, smoke or fog in the environment. They provide an effective means to detect the movement of any objects under surveillance that would trigger further actions, and greatly enhance the effectiveness of the surveillance system. It will not only provide reliable security surveillance and tracking trespasser in a dark environment, but also further help dim down lightings in essential open areas and service roads etc. to only one-quarter of normal power in normal dark hours, at a minimum of 25 lux illumination. This is a strategic approach to enhance energy saving and to minimize light pollution in open areas in the new STWTW.

A triple-control illumination system is applied for open area lighting and security lighting, viz. a 3-step dimming to 1) none or minimum illumination overnight; 2) to a mid-lighting level which is regarded as a minimum environment for safe walking and patrolling in sensing movements by TVBSS system or by manually setting; and 3) the highest

intensity level for safe work and inspections. Different precincts within STWTW have different lighting requirements and hence different energy consumptions. Hence, zoning for lighting will help energy saving at the precincts that lighting in dark is not a prerequisite. The two different zones of open area lighting of STWTW are i) essential zone including all roads and major buildings; and ii) idling zones including plant area such as filters and water tanks. The criteria and operating regimes recommended for lighting designs over different open area zones and security lighting are summarized at below Table 1. Moreover, energy saving is achieved through the use of LED lighting.

Location / Zone		Base lighting in dark hours	Triggered by TVBSS / Manual Override	Full Intensity during Work/ Inspections on Manual Demand
Open Area Lighting	Essential Zones	25	75	150
	Idling Zones	0	75	150
Security Lighting	Boundary Walls & Fencing	25	75	150
	Security Gate House	75	150	N/A

Table 1: Triple-Control Illumination System Illumination Levels (LUX)

The total greenery areas for the reprovisioned STWTW is not less than 30% of its total site area. The greening strategy aims at creating and attractive environment which is coherent with the building layout for staff and visitors. The site landscape is organized on a linear framework which aligns with the grid form of the building roofs to provide logically connected outdoor space for staff, low-maintenance and robust greenery around the treatment process precinct. The design brings the landscape features into the site which provides woodland areas, green roofs and boundary evergreen planting with native species adding a natural quality to the space.

5. CONCLUSION

This paper summarizes the designs regarding to the sustainable building development of the reprovisioning of STWTW. Having the administrative building and treatment process precincts imbedded in creating a synergy and coherent relation with the topological character, the buildings and landscape features as a whole integrate with the surrounding environment and the adjacent land users.

The sustainable designs, including green roof system, natural lighting system, rainwater harvesting, ice storage system, hydro power generator, and the thermal network camera system, enhance energy saving and minimize the environmental impact to the neighbourhoods.

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