A rendering of the completed project

DESIGN, BUILT AND OPERATE FIRST STAGE OF TSEUNG KWAN O DESALINATION PLANT

The desalination plant is a strategic infrastructure by the Water Supplies Department of the Hong Kong Special Administrative Region Government. By adopting reverse osmosis[1] technology for seawater desalination, the plant aims to diversify the water supply resources and provide reliable, adequate supply of potable water for Hong Kong.

The plant site, located at Tseung Kwan O Area 137, has lower turbidity and suspended solids levels in the offshore waters with relatively stable water quality and salinity levels, making it a preferable site for a seawater desalination plant. Since it is located approximately 2.5 kilometres away from the nearest residential area, the impact to the nearby communities during construction is minimal.

Upon commissioning of the first stage of the project, the production capacity of potable water will be around 135,000 cubic metres per day, equivalent to 5 per cent of daily freshwater consumption. The ultimate capacity of the plant will reach 270,000 cubic metres per day following future expansion.

The experience gained from this project in incorporating advanced technology; environmentally friendly equipment; innovative design solutions; and sustainable safety protocols will be carried forward to future public and private projects.

SUSTAINABILITY FEATURES

The plant is designed with a mission to reduce environmental impacts caused by its construction and operation. It has attained the highest rating of Provisional Platinum under BEAM Plus New Buildings V1.2[2] with a score of 88, significantly higher than the minimum requirement of 75.

A number of resource-saving features have been incorporated to maximise energy efficiency, cost-effectiveness and land use without compromising operation flexibility and efficiency. For example, the adoption of soft landscaping over the site, such as green roofs, vertical greening and landscape gardens, can mitigate the heat island effect; reduce energy consumption in air-conditioning; and facilitate drainage. Moreover, more than 1,800 solar panels will be allocated on building rooftops to generate renewable energy as well as to reduce energy use and carbon emissions. A large-scale solar photovoltaics (PV) farm with a power generation capacity of 10 megawatts to be installed on top of a nearby landfill is under planning. The renewable energy generated from the PV farm will be for the exclusive use of the plant.

Additionally, an integrated structure combining flotation and filtration processes is built to pre-treat seawater. Such a combined arrangement will save the footprint of the plant. Within the reverse osmosis seawater desalination process, positive displacement energy recovery devices will recover up to 96 per cent of the hydraulic energy from brine and transfer it to the feed stream for reducing the required pumping energy. Moreover, a pressure centre configuration for the high-pressure pumps allows the use of large fixed speed pumps with efficiency greater than 89 per cent. As for water conservation, the implementation of rainwater harvesting for irrigation, adoption of native species and reuse of bleed-off water from cooling towers for flushing will greatly help reduce the total water consumption.

The plant also includes an on-site chlorine generation (OSCG) facility to sustain its chlorine supply to use for process treatment. Chlorine will be produced according to the required volume and used immediately to prevent on-site storage. The delivery of chlorine drums from off-site sources is, therefore, not necessary. This can avoid the risk of chlorine leakage and human exposure to the chemical during storage and transportation. It is anticipated that the OSCG will become mainstream in Hong Kong's water treatment to create a reliable and safe source of chlorine.

TECHNICAL CHALLENGES

Since the project involves various stakeholders from different countries, it was challenging to coordinate across multiple time zones and work locations in the design stage. To make sure the design process and construction work sequence are in good progress, project information is centralised in a common data environment (CDE) platform. As opposed to the traditional file transfer protocol (FTP) server-based approach, a CDE is an online tool that has access control and allows each discipline to instantly gather synchronised information with up-to-date models, which is then federated out to the master building information modelling (BIM) model. This has greatly optimised the decision-

General view of the plant

Reverse Osmosis Building—the heart of Tseung Kwan O Desalination Plant

Assembly of tunnel boring machine at the combined shaft

making process as well as reduced the cost and time for collaboration among the various parties in the project team. As a result, the project was fast-tracked to be designed and constructed in less than four years and within budget.

For construction, one of the major marine works is the installation of two underwater pipes: one to extract seawater for desalination—the intake pipe extending approximately 330 metres from the shore; and the other to discharge brine back into the sea—the outfall pipe extending approximately 270 metres from the shore. A 1.65-metre diameter outfall tunnel was constructed in rock while a 2.5-metre diameter intake tunnel was constructed in mixed ground. Instead of building two separate launching pits on land for the two tunnels, a common wall that combines the intake and outfall shafts was constructed to serve as the thrust wall of the outfall tunnel boring machine (TBM). This enabled the two TBMs in their respective directions to launch concurrently, and a reduction in the required footprint, construction time and cost.

The biggest challenge faced during the marine construction was to successfully retrieve the intake and outfall TBMs from deep under the sea. Apart from the main drive, steering cylinder and powerpack commonly used for TBMs, a subsea recovery module and an airlock chamber for hyperbaric intervention were also installed to facilitate the retrieval. Divers manually connected the lifting system to the TBM using the crane barge and the intake TBM was safely delivered back to the ground—it is a new approach for TBM retrieval in Hong Kong. Meanwhile, the outfall TBM was dismantled and retrieved in sections from a dry shaft.

EFFECTIVE USE OF TECHNOLOGIES

To enhance construction efficiency and site safety, various technologies have been applied in the project such as BIM; CDE; digital fabrication; as well as augmented reality and virtual reality. Additionally, over 100 sensors were installed around the site to monitor construction activities, including tilt sensors near a rock slope to provide warning in case of sudden movement of large boulders. Temporary monitoring systems for openings in buildings allow instant detection of unauthorised access. A centralised management platform integrated with BIM models was developed to provide a real-time visualisation platform for the control of a series of smart devices. These include surveillance cameras with artificial intelligent functions; lifting appliances and lifting gears management system; global navigation satellite systems; and more.

References:

[1]https://www.tkodesal.hk/How_does_desalination_work
[2]https://www.hkgbc.org.hk/eng/beam-plus/beam-plus-new-buildings/

Delivery and installation of reverse osmosis modular skids

Retrieval of tunnel boring machine at outfall cofferdam

PROJECT DATA

Project Name
Design, Built and Operate First Stage of Tseung Kwan O Desalination Plant

Location
Tseung Kwan O Area 137, Hong Kong

Status of Construction
In Progress

Expected Completion
December 2023

Site Area
5.6 hectares

Gross Floor Area
28,571 square metres

Building Height
The Administration Building: 5 storeys; other blocks: 1–2 storeys

Number of Blocks
15

Client/Owner/Developer
Water Supplies Department of the Hong Kong Special Administrative Region Government

Consulting Engineer
Binnies Hong Kong Limited (formerly known as Black & Veatch Hong Kong Limited)

Design Engineer
WSP (ASIA) Limited

Design Checker
Asia Infrastructure Solutions (formerly known as Arcadis Hong Kong Limited)

Main Contractor
AJC Joint Venture (Acciona, S.A., Spain; Jardine Engineering Co. Ltd, Hong Kong; and China State Construction Engineering (Hong Kong) Limited, Hong Kong)

Images
Water Supplies Department