Performance Synergy from Integrated Design, Construction and Operation. Case Study on a High Performance Grade A Office - Swire One Taikoo Place

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ABSTRACT

Taikoo Place Phase 2A Tower (TKP2A) is Swire Properties Ltd new and prestigious office development project. It is redeveloping Somerset House in Taikoo Place on Quarry Bay, Hong Kong with a target occupation date in 2018. The key objective of TKP2A is to develop a best in class, green and sustainable building from demolition, design, construction to operation. This will be a leader of high performance sustainable buildings in Hong Kong.

TKP2A embraces modern integrated design. This positions sustainability at the key elements of design and brings the design team together from the earliest project stage to jointly develop solutions. This fosters innovation and the application of new technologies and processes.

With the desire for TKP2A, to push low carbon construction significantly beyond what had already been achieved across current Swire's Building properties it was essential to approach design from a non-conventional starting point. From this early vision a design team was formed, with green and sustainability as the core values at the heart forming a design platform and integrating the multidisciplinary design team together with various departments from Swire Properties. At this early stage, project goals were set and every member of team was empowered to develop towards these goals through design charettes and regular workshops. This ensured that future challenges were identified early and mitigated, enabling a new level of low carbon construction to be attained.

This integrated design process and key elements of design are discussed in this paper.

***Keywords**: integrated design, sustainable construction, high performance*

1. INTRODUCTION

Taikoo Place Phase 2A Tower (TKP2A) is Swire Properties Ltd new and prestigious office development project. It is redeveloping Somerset House in Taikoo Place on Quarry Bay, Hong Kong with a target occupation date in 2018.

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With the desire for TKP2A, to push low carbon construction significantly beyond what had already been achieved across Swire's Building Stock it was essential to approach design from a non-conventional starting point. From this early vision a design team was formed, with Arup's Building Sustainability group at the heart providing design platforms and integrating the multidisciplinary design team. At this early stage, project goals were set and every member of team was empowered to develop towards these goals through design charettes and regular workshops. This ensured that future challenges were identified early and mitigated, enabling a new level of low carbon construction to be attained.

This integrated design process and key elements of design are summarised in this paper.

Figure 1: Rendering of TKP2A

2. INTEGRATED APPROACH TO HIGH PERFORMANCE BUILDING

Sustainability in the context of today's building market has taken on a holistic nature where many different initiatives are required to interact to enhance and sustain the triple bottom line: environmental, social and economic drivers.

The design of the building must embed systems, technologies and interfaces that enable operators and occupants to achieve the highest sustainable performance throughout the buildings life.

Excellent cross-team coordination and integration work is crucial for the project to achieve real performance enhancements. Starting from the early design stage, the TKP2A project team together with Swire Properties building operational team and Swire Properties sustainability team had a deep involvement in the TKP2A design. This wealth of building operation experience was essential in developing design driver. As such, TKP2A was designed by occupant and operational needs. The measured energy performance data of several buildings in Taikoo Place was given to the design team for them to identify a genuine energy performance benchmark. The design team could then test the performance of various green strategies against this benchmark.

A number of charrettes occurred across the project team, design team and operational teams at early stage. These included facade, sustainability, mechanical and electrical systems, demolition, green construction etc. The charrette acted as a communication platform to highlight the requirements of performance quantification, operational and maintenance activity, design constraints etc. It was a key and successful tool in project delivery.

3. SUSTAINABLE DEMOLITION

To first task was the demolition of Somerset House. As such a sustainable waste management plan was developed. Sustainable demolition aims to minimise the use of resources, i.e minimising waste sent to landfill.

Through in depth discussions with the structural engineer an understanding of the safe execution of demolition processes, waste handling procedures and waste sorting methods were developed. Then a sustainable waste management strategy was proposed which outlined demolition waste and material treatment. Three hierarchal principles were followed:

Waste avoidance

Reuse of materials is the most effective way to minimise waste generation, Swire Properties collaborated with local charities to donate fixtures and fitting for onward distribution to the needy. This extends the fittings service life and avoids waste by reuse of good quality of interior fittings such as furniture, carpet, electrical appliances and equipment. A number of local charities or institutes are in operation e.g. Crossroad, Industrial Relation Institute etc. There are also some waste recycling programs organized by local government e.g. Computer Recycling Programme by the Environment Protection Department which will collect donated computers and electrical appliances for onward distribution.

Waste recovery

After all reusable materials are taken out, the materials are then processed for recycling. The main source of waste is the permanent structure of Somerset House accounting for over 86% of waste by weight of the whole project, over 70,000 tonnes. There are several waste concrete recyclers in Hong Kong. Over 75% of the broken concrete (normally smaller than 400mm in size), plus other inert C&D waste including rocks, boulders, rubble and bricks were distributed to local recyclers for recycling. These inert wastes go through a series of crushing and screening processes to become recycled aggregates of different grades. Recycled aggregates serve a wide range of applications including road sub-bases, filter layers, ingredients in concrete and the filling of bridge columns. The broken concrete will also mix with the recycled glass sand and titanium dioxide to form eco-paving blocks which will be re-utilised in hard landscaping.

Another major source of waste is the reinforcing steel bars in concrete structures and aluminium scraps from window frames. Processes for metal recycling are common and these materials were easy to recycle.

The overall performance of demolition waste recycling for TKP2A is over 75% by accounting for waste not taken to the local public fill. Approximately 35,300tons of embodied carbon was be saved by the reduction of virgin materials.

Figure 2: Recycling of waste metal in TKP2A project during demolition

4. LOW CARBON CONSTRUCTION

Swire Properties take a great effort on the sustainable development industry. With closely collaboration with Swire's Technical Services and Sustainability Department (TSSD), the embodied carbon for material selection and carbon emission during construction has been evaluated and managed properly.

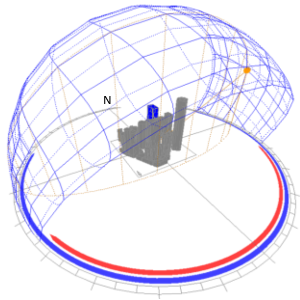
The embodied carbon of building materials can be taken as the total carbon emissions released over its life cycle. This includes the process of extraction, manufacturing and transportation. Several low carbon construction strategies have been considered during the initial design stage in order to avoid large wastages of materials in TKP2A tower.

4.1 Utilization of low carbon material

Use of high recycled content materials which are regionally sourced can significantly reduce the emissions of embodied carbon from transportation and raw material extraction and manufacturing. Strategies to reduce of all these factors were considered.

Concrete mixed fly ash – TKP2A uses fly ash to replace cementious material in concrete, as cement has a very high embodied carbon content to add significant benefit.

Reinforcement steel is a major material in high rise buildings. It is common to adopt around 10% to 20% recycled metal into the steel.



Use of regionally manufactured and sourced materials within the project can effectively reduce transportation carbon emissions. According to the international green building certification system – LEED Core and Shell, a regional material is defined as material which is extracted and manufactured locally within 800km of the site. The overall target of recycled content of materials and regional manufactured material is 20%.

4.2 Higher flexibility for interior layout design

With the collaboration with architectural and structural design team, a range of initiatives are adopted in the design in order to avoid excessive material consumption and wastage due to frequent changes of tenant layout.

Knock-out panels were designed into the floor slabs. These reduce the additional renovation works for the installation of internal escalators or staircases by future tenants. Integration with the structural engineer is required in order to locate this movable panel into the building structure.

Application of digitally addressable wireless control systems for lighting. This allows for the easy adoption of various zoning and lighting control strategies based on tenant's needs by programming and eliminating any additional wiring works for future tenant rezoning. Installation of additional energy saving controls e.g. occupancy sensor, daylight harvesting is relatively simple when using wireless control systems.

5. IN USE ENERGY CONSUMPTION & CARBON EMISSIONS

TKP2A has been designed to minimise operational carbon emissions. This requires a number of integrated initiatives across the energy design hierarchy. Through the design platforms, design charettes and integrating the multidisciplinary design team at this early stage, the building operational consideration and the characteristic of energy consumption for existing buildings nearby the project site has been referred and a more suitable design approach that fit the needs for TKP2A has been identified. This design hierarchy ensures that building loads are minimised with passive design before they are served with highly efficient active services and finally grid supplied electricity is replaced with renewable energy.

5.1 Passive design

Passive energy design is reduction of building loads with the use of architectural features. The excellent thermal properties (solar controlled glazing and opaque insulation) of the building envelope effectively insulates the building from Hong Kong's hot climate.

The external shading devices which were designed in response to TKP2A's solar environment, help to further block the unwanted solar heat gain throughout the year. The overall OTTV of proposed model is around 19W/sq.m. in the office tower as compared to the statutory maximum OTTV requirement for offices of 24W/sq.m.

At the same time as blocking solar heat gain the glazing also allows the whole office tower to experience daylight. Artificial lighting is automatically dimmed when daylight is present. This reduces artificial lighting energy consumption.

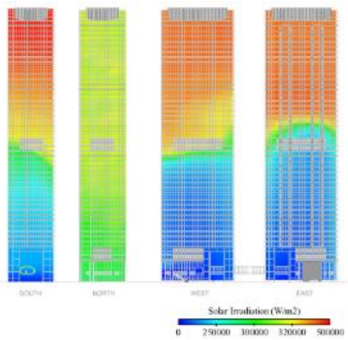


Figure 3: Sun path analysis and solar heat gain study from building envelope

5.2 Active design

TKP2A includes a range of energy saving systems which enable the building to substantially reduce energy consumption beyond local and international code. With collaboration with architectural team, building services design consultant and Swire TSSD and Taikoo Place Management Office (TPMO), a selection of the key systems are noted here.

High Performance Chiller and Plant Optimization. Cutting edge, high performance centrifugal variable speed chillers and optimised chiller sequencing will deliver cooling effectively for the buildings life. Starting from the review of chiller plant operational data from existing buildings, together with the consideration of condenser water temperature and building loads, chillers dynamically adjust and operate at the optimum efficiency in order to obtain an optimization control and operation. This strategy obtained around 5% of total building energy consumption.

100% Free Cooling and Air Economisers. The side core design in TKP2A enables floor by floor fresh air intakes. This in turn increases the potential fresh air intake volume allowing 100% free cooling with an air economising. This cooled air system enables a chiller bypass when the outdoor conditions are cooler.

Demand Control Ventilation. Carbon dioxide (CO2) levels are a good measure for the fresh air requirements as people breathe out CO2 and require more fresh air. CO2 monitoring systems in the office area of TKP2A detect the occupancy levels so that the amount of fresh air can be adjusted in accordance with the demand. A similar system in the car parks detects carbon monoxide. These detectors are installed in basement car parks to monitor the pollutant concentration levels and modulate fresh air delivery based on traffic conditions.

Energy recovery

When stale and cold air is exhausted from buildings it contains useful energy, heat recovery collects this useful energy for use in the building. The high efficiency heat wheel has been designed to recover energy from office and toilet exhausts.

High efficient lighting

Lighting energy is a major consumer of energy in office buildings. The lighting design has, optimised lighting lux levels, high energy efficient light tubes and high reflective luminaires as well as an effective lighting grid arrangement. These measures reduce lighting power levels by almost 40% compared to local code levels.

Efficient air movement

Moving air around buildings with fans consumes significantly quantities of energy. High efficiency fans with brushless direct drive motors (EC plug fan) are a new technology which reduce fan energy consumption by almost 20%.

The overall building energy saving for the proposed TKP2A is about 33% as compared to the HK Building Energy Code Version 2012 as baseline. The annual building energy cost saving is about 28% as compared to the ASHRAE Standard 90.1 (2004) baseline setting.

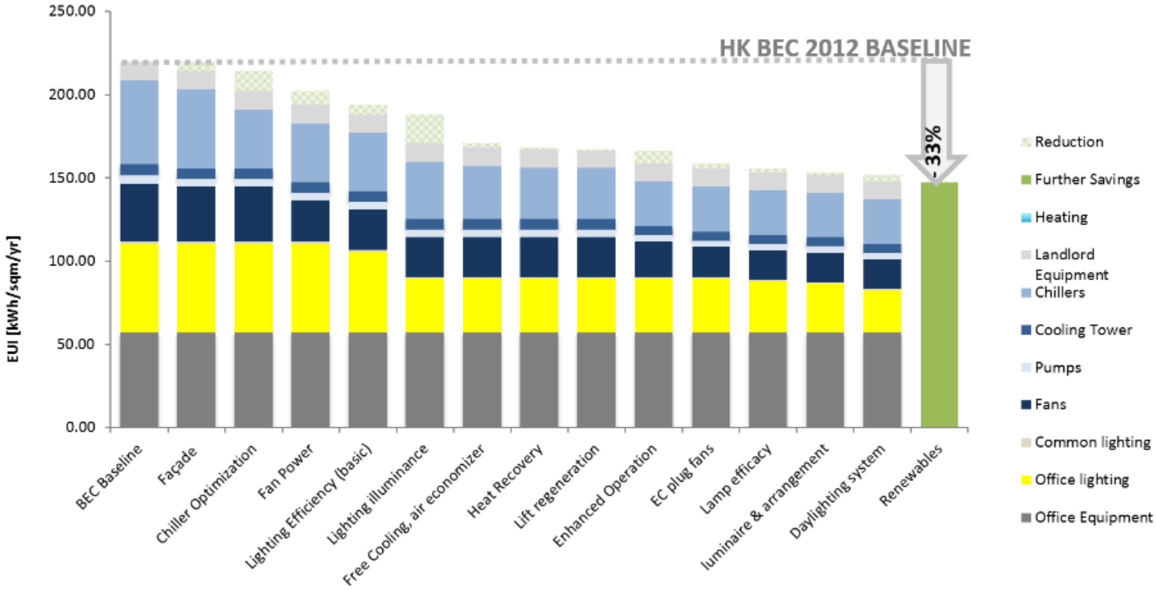


Figure 4: Annual energy reduction of TKP2A from HK BEC 2012 baseline

5.3 Waste to renewable energy

After application of passive strategy and active system, large portion of building energy has been reduced. On-site renewable energy generation is one of the strategy to further reduce the residual energy of the building. For a high-rise high energy intensity building with limited building footprint and usable roof area, TKP2A pushed the boundaries and worked with the government to introduce waste cooking oil power generation. A commercial building first in Hong Kong.

In Hong Kong, an estimation of 20,000 tons used cooking oil and 175,000 tons of grease trap waste each year are generated from eateries and food businesses which is typically disposed of at landfill. Hong Kong's landfill sites are going to be exhausted by 2020. The Environmental Bureau has set a target of a 40% reduction in food waste to landfill by 2022. To help achieve this, food waste can be used for bio-diesel production. Biodiesel is normally made from feedstock such as used cooking oil, grease or disposed animal fats.

The 200 kW (electricity) bio-diesel generator proposed for TKP2A consumes 540L a day approximatly of B100 grade bio-diesel made of 100% food waste. Eventually around 135,000L of waste cooking oil will be reused annually. Provided the waste oil production from F&B tenants and hotels in Swire's protfoilos approximates 20,400L annually, all the used cooking oil could be utilized by the power generation plant. 15% oil demand of generator is fulfilled and there is sufficient capacity to take up more waste cooking oil from other from eateries and food businesses. As such TKP2A bio-diesel generator completes the cycle of waste-to-energy for the community.

The generator provides electricity for the building and the waste heat from the generators is used to generate cooling. This energy cascade maximises the usable energy from the system. In energy terms, over 400 MWhrs of renewable energy is generated. It is equal to 278 tons of CO2 emission being off-set by 1400 trees. It provides over 2% of the total building electricity consumption.

5.4 Wind performance and outdoor comfort at open space

The new development will contain a range of public spaces, streetscape amenities and a new elevated walkway corridor naming Taikoo Plaza and Taikoo Gardens that will enhance the setting and context of a distinctive and emerging area of Hong Kong. The concept for this landscape proposal is a contemporary reinterpretation of the landscape that surrounds the city of Hong Kong with its particular geological nature and cultural refinement through craftsmanship using noble materials.

Figure 8: Masterplan of Taikoo Place

Vegetation

Provide highly vegetated areas and dense planting to reduce urban heat island effect and improve the micro-climate within the scheme. Address the green ratio requirements. It also minimizes the impact on urban heat island effect. Compared to the existing development having 3 buildings, the current building plan with massive public space and greenery obtain around 2^{o}C reduction at local area.

Sustainability

Provide an enhanced environment to the neighbourhood where sustainable techniques can be included to mitigate energy use, water consumption, air pollution and bring a potential layer of biodiversity into the site especially within the core landscape areas. Provide an enhanced environment to the neighbourhood where sustainable landscaping techniques can be included to reduce energy use and water consumption and mitigate air pollution as well as urban heat island effect.

Social connectivity

Create an inclusive landscape and open space framework that encourages outdoor activities, promenading and passive recreational activities, where residents, workers and visitors can have an enjoyable and calm experience relaxing, meeting and mingling in an outstanding urban landscape.

6. FURTHER SUSTAINABILITY

Other than the material use reduction and operational carbon emission reduction, the project team also considered other sustainable design elements which further enhanced the building performance and thus beneficial to the building occupants.

6.1 Performance verification of design elements

Project team put an effort on the performance verification and design review on the system and key design elements by modelling and simulation. For example, a computational fluid dynamic (CFD) model has been applied to verify the air distribution effectiveness of AC system. The solar irradiation with 3D rendering tool has also been applied to verify the performance of PV system and analyses the reflective glare impact to surrounding buildings. It built up a sophisticated quality control measures for TKP2A and a new practice to future projects.

6.2 Enhancement to future tenants and building operators

With an integrated collaboration among the architect and MEP engineers during design stage, additional centralized exhaust systems were designed into the central core. These are available for future tenants to connect their individual exhaust ducts to for air exchange during fit-out periods. This minimizes the spreading of odours and cross contamination between tenants. Further collaboration with operational and maintenance team would help to understand further the needs and criteria from the building users. Earlier involvement with O&M team would also help enhancing a more user-oriented design to this project.

7. CONCLUSION

The demolition, construction and ongoing maintenance of buildings consumes significant quantities of resources. This is particularly prevalent in the higher end property market which demands the best of current provisions. As such TKP2A followed a focused approach to sustainability where by all possible efforts were made to reduce resource consumption. As was noted in this paper, this process was driven by Arup's Building Sustainability team, and involved the integration of all members of the design team, project team and operation teams from the early stage to realize the vision of Swire Properties.

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