FUTURARC
NEW ARCHITECTURE

3rd quarter 2008 | volume 10
MICA (P) 255/10/2007 / KDN, PP14474/1/2009

GREEN
ISSUE 2008
Provocations.
Projects.
People.
GREEN AIRPORTS
by Deborah Singerman, Candice Lim and Caroline Wang

Naturally lit, transparent, and well-louvre'd for minimal solar glare and heat gain; energy efficient; and landscaped with greenery—three recently completed airport terminals seem to be aiming for green in similar ways.

HEATHROW TERMINAL 5

Variously described as "Europe's busiest airport" and "the world's busiest international airport", Heathrow, on the outskirts of London, has a reputation to live up to. However, it has also been tagged with other less flattering labels—chaotic, badly organised, dowdy, and a nightmare to get around.

The new £4.3 billion ($11.6 billion) Terminal 5 campus development includes the main terminal (Heathrow's first major new terminal for over 20 years), two satellite terminals (the second to open in 2010), a control tower, landscaped motorway link, taxiways, aircraft stands, rail stations for trains to central London and beyond, an airside track transit system and road tunnels to the airport's central terminal. This massive re-fashioning in appearance and functionality is aimed at turning arrival and departure into a pleasurable passenger experience.

T5 was officially opened by Queen Elizabeth II in March 2008, almost 20 years after the architects, Rogers Stirk Harbour + Partners (RSHP—formerly Richard Rogers Partnership), won the competition, and began the master planning and shell-and-core design. It hit the headlines for all the wrong—and unsustainable—reasons: baggage handling problems, IT system breakdowns, flight delays and passengers kipping wherever. At the time of writing, BAA and British Airways had deferred moving long-haul services from Terminal 4 to T5 until June but things generally were operating normally. Come what may, the bright, airy terminal—all 300,000 square metres with an expected 30 million passengers annually—demands attention. While it is too early yet for operating costs and monitored performance figures, sustainability, as the architects say, "has been a core value in delivering T5". It is also a commitment from the client, airport owner and operator BAA, and from T5's exclusive airline, British Airways.

T5 needed to be compact and sit within a constrained footprint as a result of a public inquiry completed in 1999, which insisted that the site area must not cover surrounding green belt land as originally intended.
RSHP, led by project director Mike Davies, wanted “a sustainable, long-life, loose-fit concept allowing for flexibility, growth and change over time”. They have created a large floor plate concept with, in the architects’ words, “an unencumbered large-span envelope” that leads to just the flexible, internal spaces required, and easily dismantled and reconfigured facilities within a freestanding steel-framed structure. The immense, elegant “curved floating roof”, up to 37 metres high with a clear span of 157 metres, is supported by slim columns at the perimeter edges.

In line with many airport terminals—indeed new, large commercial buildings the world over—RSHP have favoured natural light and transparency throughout the passenger areas, which are mainly on one level though extending over two levels at both ends of the building. The plant room and baggage handling are below. Open and fully glazed louvred façades, using a brise-soleil shading system, add to the effect, allowing passengers to see across the airport while also limiting glare and solar gain. As well as improving the overall ambience within the terminal, all this reduces the need for artificial lighting especially during the day, and optimises energy use. A control system switches off or reduces lighting levels within the terminal when parts of the building are not in use. Remote controlled energy metering within this system is aimed at improving energy management, saving energy while also allowing the new terminal to meet Part L of the British Building Regulations controlling carbon emissions from buildings created by their environmental services. The Society of British Aerospace Companies Chief Executive Ian Godden reiterated the industry’s ongoing Sustainable Aviation strategy to cut noise and carbon dioxide emissions by a further 50 percent of 2000 levels by 2020.

T5 uses waste heat to reduce its gas consumption. An energy centre is connected to a combined heat and power plant, which generates 15 megawatts of electricity distributed on the Heathrow high voltage distribution system. Waste heat associated with this process is recovered and distributed back to the energy centre where it will supply approximately 85 percent of T5’s heat needs. This is expected to reduce gas consumption by 85 percent with a corresponding reduction in carbon dioxide of 11,000 tonnes per annum. Hydrochlorofluorocarbons (HCFCs) have almost been completely eliminated from the T5 project. It was decided early on that the most efficient and environmentally acceptable solution to cooling the building was to use a centralised chilled system, with the chilled water being generated by high efficiency ammonia chillers to avoid the use of HCFCs, which have a very high global warming potential.

Deciding that natural ventilation was impractical because of aircraft noise and pollution, the architects used a displacement air-conditioning system developed by Arup, the project’s structural engineer. This system distributes air out to the floor plates, directly where it is required, recirculating air and minimising use of fresh air. Air quality and temperature is measured by T5’s building management and control system.

Groundwater boreholes and T5’s own rainwater harvesting scheme supply water for non-potable uses such as toilet flushing, irrigation, energy centre cooling and vehicle washing. The system is able to capture and reuse 85 percent of the rainfall that falls on the entire T5 catchment. Demand from the public water supply is expected to be reduced by 70 percent. Alongside additional water-saving devices such as dual-flush toilets and taps; showers with automatic on and off sensors; and aerated flow, the passenger terminal is predicted to reduce consumption of potable water from 40 litres per person to 17 litres per person.

BAA has a strict materials strategy, focusing on sustainable construction materials and minimising the use of non-sustainable or harmful materials. For instance: only Forestry Stewardship Council-approved timber from sustainable sources was used; over 300,000 tonnes of aggregate was processed and recycled on site from demolition materials and waste concrete; crushed green glass from domestic household recycling banks was used as a base for T5 site roads; around...
CHANGI AIRPORT, PASSENGER TERMINAL BUILDING 3

While skylights do not represent anything unique, when multiplied 919 times across the huge rectilinear main roof of Singapore Changi Airport's latest terminal, it starts to gain a certain impressiveness. Terminal 3's ‘butterfly’ roof—so nicknamed because of the shape of the automatic reflector panels—is a vast system of apertures that illuminate lower-level spaces, opening them up to the light above. As Singapore experiences much diffused daylight, it was only natural to capture the usable light to illuminate the series of open spaces beneath T3's main roof, while controlling the heat gain from the sun most of the day. At night, the skylights are lit with artificial lighting that makes use of the same reflector panels as the daylight system.

Designed by CP Airport of CPG Consultants Pte Ltd, T3, which cost S$1.75 billion to build, is a 7-storey structure with four above-ground levels and three basements, offering a total floor area of 380,000 square metres. The design brief for the project was to plan a new passenger terminal building that would increase passenger capacity for the airport and offer a new level of passenger service specifically in terms of passenger comfort, clarity and convenience, as well as being an architectural landmark, given an increasing emphasis on the architecture of passenger terminal buildings in the region.

The response to this was to have a main high building envelope that encloses main passenger processing and visitor areas with an interior spatial interconnectedness—while meeting all security requirements—with shaded sheer glass façades that permit a continuity with the external environment, and an expansive roof with the complexity reflected in its layering of ceiling-panels, reflectors, skylights and high-tech ‘butterflies’, articulating its rooftop-canopy inspired random-pattern build-up.

Daylighting helps reduce the energy usage for T3 by minimising the daytime use of artificial lighting. Reduced artificial lighting also results in decreased cooling load. The building's air-conditioning is thermally stratified to cool only the lowest occupied levels, approximately 4 to 5 metres in height. There are airlocks to check the loss of cooled-air and intelligent building management sensors to control lighting, lifts and escalators and operable-shading usage. Using thermal stratification, the cooling capacity required for T3 is only 115W/m², compared to the earlier Terminal 2, which is 180W/m². The sub-surface carparks at either end of the main terminal also utilise landscaped openings down their sides to draw in fresh air for ventilation. The overall energy consumption for T3 is estimated at 20kW/m² versus about 24kW/m² for each of the earlier terminals. T3 continues the airport's system of rainwater reuse via the on-site reservoir; the non-potable water is used for irrigation and toilet flushing.

Another distinctive highlight of the terminal is its interior landscaping—made possible by the high daylight levels— including a 15-metre high vertical garden called "The Green Wall". Spanning 300 metres across the main building, it is covered with climbing plants and interspersed with four cascading waterfalls. A soothing visual delight, it can be seen from the departure and arrival halls, and baggage carousels.
BEIJING INTERNATIONAL AIRPORT, TERMINAL 3
Designed by Beijing Architectural Design and Research Institute and NFA (a joint venture of NACO, Foster and Partners and Arup), Terminal 3 of Beijing International Airport is composed of two sections—T3A (main building and concourse for domestic flights) and T3B (main building and concourse for international flights). With a total floor area of over 900,000 square metres and total curtain wall area of 330,000 square metres, T3 is the biggest standalone terminal building in the world. To achieve energy saving goals for such a massive structure is no easy task.

T3 depends solely on natural lighting during the day: The transparent glass curtain wall allows sunlight to penetrate, eliminating the need for artificial lighting during daytime; the 155 dragon scale-shaped skylights on the roof also introduce beams of light into the interior and the curvilinear roof deflects the light beams and creates an interesting play of light and shadow. The positioning of skylights was carefully calculated to ensure even distribution of sunlight. They are oriented towards southeast to introduce warm, soft sunlight in the morning and avoid strong direct sunshine in the afternoon. The glass curtain wall is designed at a 15-degree angle to reduce solar gain on the exterior wall, keeping the indoors cool while reducing energy consumption. Cantilevered eaves on the perimeter of the building also act as sunshades for the curtain wall. According to Shao Weiping, Executive Chief Architect of Beijing Architectural Design and Research Institute, one of the principal designers of this project, the main eaves are extended to 40–60 metres on the south elevation to effectively fend off direct sunlight. The general heat transfer coefficient of the glass curtain wall is kept at about k=1.9 W/m²K with heat bridge treatment on the aluminum alloy beams and insulation between glass panels.

Its ground transportation centre is covered with a green roof. The earth cover provides multiple benefits especially for northern China: It keeps the building warm in winter and cool in summer, thus reducing the building’s energy consumption; it also helps improve the local ecological environment and visually reduces the mass of the structure, giving the huge building a more human scale.

Advanced mechanical approach and technologies are incorporated in T3 to complement passive design methods in order to achieve maximum energy efficiency. T3’s intelligent lighting system—which automatically monitors and controls lights in different functional areas according to the time of the day, light sensor feedbacks and flight schedules—combined with energy-efficient luminaries, save over 10 percent of energy consumption, amounting to about 160kwh per year based on initial estimates. Light sensor controls are activated during passenger traffic peak hours, which means when natural lighting exceeds the set light strength, lights will be turned off automatically and vice versa. Movement sensors will kick in to replace light sensors at night when traffic is low; as people move along, lights in different areas will be turned on or off.

The air-conditioning system is equipped with air ventilator wheels with total thermal recovery that will cool and dehumidify fresh air in summer, and preheat...
and humidity fresh air in winter. The air-conditioning system uses recycled cold air. Zhu Jingyuan of China Civil Airport Construction Corporation explains: “Fresh air is not blown from top down; instead, cool air stays in the area where people move about, which not only saves energy but also functions as insulation.” T3 is also equipped with 26 environmentally designed smoking rooms. These rooms each has two ozone generators that suck in the smoke before it spreads, keeping the air fresh.

A district energy system enables efficient use of energy in this project: hot fumes released from gas turbines when generating electricity is used to produce mid-temperature, mid-pressure steam, which drives steam turbines to generate electricity. In summer, part of the steam will be used for cooling water for the air-conditioning system while in winter, the steam can be directly used for heating, with heat from the steam condensation being used for hot water supply. Approximately 44 percent of the gas will be turned into electricity; the system also uses little extra water. In addition, the gas turbines adopt low nitrogen oxide burning technology, keeping the emission under 25 parts per million.

To control emissions of pollutants into the atmosphere, Beijing Capital International Airport Company Limited invested close to RMB1.7 million to install an online monitoring system for the solid waste incineration plant’s flue gases and sewage purification plant. The system keeps close watch on the flue gases and sewage by-products, and sets off alarms when the amount of waste released exceeds the permissible level.

PROJECT DATA
Project Name
Terminal 3, Beijing Capital International Airport
Location
Beijing Capital International Airport, Beijing, China
Completion
December 2007
Site Area
1.3 million m²
Gross Floor Area
966,000 m²
Building Height
45 meters
Client/Owner
Beijing Capital International Airport Company Limited
Architecture Firms
Foster and Partners, NACO, Beijing Architectural Design and Research Institute
Principal Architects
Norman Foster, Shao Weiping, Zhu Jingyuan

Main Contractors
Beijing Urban Construction Group Co., Ltd (T3A), Beijing Construction Engineering Group (T3B)
Images/Photos
Brian Sun