Located in the metropolitan city of Tokyo, the new YKK headquarters building is named “YKK 80” because it was completed in 2014, which marked the 80th year since the company was founded.

Tragically, in March 2011, just one month after design began, the Great East Japan Earthquake and disaster occurred. Japan rapidly shut down all of its nuclear power plants (nearly 30% of Japan’s total energy supply) and reassessed its energy supply and demand as well as its seismic vulnerability. This allowed the owner and design team to reassess the energy, comfort, sustainability, and seismic design requirements for this project—ultimately leading to a much more innovative, integrated, comfortable, healthy, and resilient design solution.

The project site is a five-minute walk from Akihabara Station, and the longer axis of the site is 70 m (230 feet) in length, faces westward, and overlooks a metropolitan area.
expressway. These constraints immediately established several energy, daylight, noise, and view design challenges for the hot and humid summer climate of Tokyo.

**Energy Efficiency**

Using a passive first approach, an exterior “sudare screen,” or Japanese traditional blind (Photo 1), was used over the entire west-facing façade to block and filter direct solar gain while maintaining daylight and views. This sudare screen is positioned 1.5 m (~5 ft) in front of the glazed façade using the cantilevered floor structure as overhangs. The screen is made of “Y”-shaped aluminum bars, providing a delicate filtering of light. Clear double glazing with automatically controlled bottom-up or “climbing” blinds also provide solar shading while still allowing exterior views.

Daylighting is maximized by controlling the light coming through the windows with automatic solar adjustment of the angle of the blind slats every 10 minutes. Through post-occupancy evaluation, which was completed in February 2016, more than 80% of the occupants were satisfied with the indoor lighting conditions noting that it was “bright enough” and “not too bright” (no presence of glare). Ceiling-integrated LED lighting, and controls for dimming or turning off lighting in vacant areas using daylight and motion sensors, extend the value of the energy-saving façade design to the indoor environment.

With direct solar heat gains mitigated and daylight and lighting optimized, a properly sized,
The expression of the façade is constantly changing as you walk around the building.

**CONDITIONED SPACE**
- **Name**: YKK 80 Building
- **Location**: Tokyo
- **Owner**: YKK REAL ESTATE CO., LTD.
- **Principal Use**: Headquarters office building
- **Employees/Occupants**: 600
- **Expected (Design) Occupancy**: 600
- **Percent Occupied**: 100%
- **Gross Square Footage**: 225,170
- **Conditioned Space**: 158,000
- **Distinctions/Awards**: 2017 ASHRAE Technology Awards First Place; LEED C&S Platinum
- **Total Cost**: $100,558,710
- **Cost per Square Foot**: $447
- **Substantial Completion/Occupancy**: 2015

**WATER AT A GLANCE**
- **Annual Water Use**: 2,553,000 gallons per year; clean water 1,592,000 gallons; graywater 788,000 gallons, which is 100% recycled water

**KEY SUSTAINABLE FEATURES**
- **Water Conservation**
  - Rainwater collection, treated wastewater, water saving appliances, recycled water used for toilet flushing and landscaping.
  - Recycled Materials
  - Concrete with high-percent recycled material, wood products with 10% recycled materials.
  - Construction materials sorted and collected for recycling, use of local and native materials.
- **Daylighting**
  - Sudare screen and clear double glazing with automatically controlled climbing blinds.
- **Individual Controls**
  - Task lighting for all workstations, air conditioning controls every 200 ft² to 300 ft².
- **Carbon Reduction Strategies**
  - Energy-efficient strategies throughout.
- **Transportation Mitigation Strategies**
  - Five-minute walk from railway station.
- **Other Major Sustainable Features**
  - Task and ambient lighting, water-saving system for toilet and heat recycling for air-conditioning system, green roof to cool the air around the air-conditioning unit.
  - The building features a thermal air-intake system, a green rooftop garden with farm-to-table food production, ongoing measurement and monthly verification, periodic post-occupancy evaluations, and MERV 13 filtration for PM₂.₅ and pollen.

**BUILDING ENVELOPE**
- **Roof**
  - Type: Concrete roof with roof garden
- **Walls**
  - Type: Concrete 140 lb (R-0.132 h·ft²·ºF/Btu) 8 in. HW concrete + R-11 wood furred insulation
- **Windows**
  - Effective U-factor for Assembly: 30.1 W/ft²·K
  - Solar Heat Gain Coefficient (SHGC): 0.14
  - Visual Transmittance: 53%
- **Location**
  - Latitude: 35° 39' 10.1952'' N
  - Longitude: 139° 50' 22.1208'' E
- **Orientation**
  - The longer axis of the site is 230 ft in length, facing westward, and overlooks a metropolitan expressway. This caused several energy, daylight, noise, and view design challenges for the hot and humid summer climate of Tokyo.

**BUILDING TEAM**
- **Building Owner/Representative**: YKK REAL ESTATE CO., LTD.
- **Architect/Engineer**: NIKKEN Sekkei LTD.
high-efficiency HVAC system could be designed. A custom, radiant ceiling panel heating/cooling system was designed to facilitate integration of hot/cold water piping with lighting and low-velocity (slight) airflow. This slight airflow concept came from the biomimetic memory of experiencing a natural breeze under the shade of a tree. Small fans, functioning as diffusers, provide the slight airflow behind the inclined radiant panels and allow greater variation in temperature setpoints.

Thermal loads in the interior zone, where the temperature does not significantly change, are met by the radiant ceiling panel system.

However, the variable thermal load near the exterior windows is met using an active chilled beam (Figure 1).

The sudare screen creates a safe service space for maintenance of exterior installed mechanical systems, and even provides lightning protection, ultimately providing six functions for a single cost (façade, shading, reflecting daylight, service balcony, maintaining views, and lightning protection).
Figure 4 DIFFERENCE OF OUTDOOR AIR TEMPERATURE AND ROOM TEMPERATURE [K]

This figure shows energy savings from YKK’s actual temperature setpoint mitigation. It shows the quantity of energy consumption for control of the sensible heat load on the vertical axis and the difference between outdoor temperatures and an average of all room air temperatures on the horizontal axis. This proved that if the room temperature is increased by 1 K (1.8°F) in cooling mode, energy savings are 8.6 MJ/h (8,150 Btu/h) or 23.3 MJ/h (22,080 Btu/h) source energy. Similarly, lowering the room temperature by 1 K (1.8°F) while in heating mode saves 12.0 MJ/h (11,374 Btu/h) or 32.4 MJ/h (30,710 Btu/h) source energy. The chilled water temperature is relatively high, which contributes to the high performance operation of the chillers.

Figure 5 CONCEPTUAL DRAWING OF HVAC SYSTEM

Mock-up verification room during the design phase using thermal mannequin.
Indoor Air Quality and Thermal Comfort

Excellent indoor air quality is maintained throughout the year by using air-handling units with desiccant-based dehumidification, a dedicated outdoor air system (DOAS), and proper control of the quantity of outdoor air based on CO$_2$ concentration. The minimum quantity of outdoor air, which is taken through the air handlers, is supplied to the space above the radiant ceiling panels. This air is continuously returned at the floor level and is then returned to the rooftop air handlers. Figure 6 shows indoor CO$_2$ concentration data on the vertical axis, which was measured by floor and time of day when the air handlers were in operation, and the average temperatures of each season (summer, shoulder seasons, and winter) on the horizontal axis. CO$_2$ concentration detects an occupant’s presence, and the power is automatically turned off when nobody is present.

Earth-to-air energy exchange occurs using an underground trench in the seismic isolation layer to preheat or precool outdoor air. In addition, well water for direct thermal exchange is used as an untapped natural resource in the lower level air handlers.

Together, this zoned approach provides for a very efficient distribution of both energy and comfort. Other energy-reduction strategies include active plug-load management and geoexchange. Each desk is equipped with an electric outlet or receptacle capable of showing electricity consumption for that desk. It is also equipped with a sensor that detects an occupant’s presence, and the power is automatically turned off when nobody is present.

CASE STUDY YKK HEADQUARTERS

Verification measurement just before the operating phase, using 400 black lights for the heat load.

SAVE YOUR ENERGY

New LPD Y Strainer dramatically reduces energy loss

Completely redesigned, the new LPD Y Strainer has a cleaner, leaner internal geometry and massive screen surface area to allow smooth, free fluid flow.

Calculate your savings at: Metraflex.com/lpd
has been maintained around 707 ppm throughout the year, indicating very good air quality. Additionally, MERV 13 filtration of supply air was used to control respirable particulate matter, pollen, and dust.

Using a detailed three-dimensional building information model (BIM) and computational fluid dynamics (CFD), comfort verification of the radiant
cooling system was confirmed during the design phase. Additionally, experiments were conducted with subjects in a mock-up research laboratory to verify comfort in areas using the slight airflow (Figure 7).

The mock-up research and lab experiment, with over 150 participants, confirmed comfort in over 75% of the participants using higher temperature setpoints with a slight airflow, demonstrating compliance with ASHRAE Standard 55-2010 (Figure 8).

Innovation
The real innovation of the YKK80 building was in meeting the challenges brought forth by the 2011 disaster and the entire owner, design, and construction teams’ commitment to use an integrated design process in response. The key innovations include: the multifunctional façade design; the “under-the-tree” breeze radiant cooling system; the design, mock-up, and lab comfort verification process; and the enhanced commissioning and ongoing measurement and verification. Today, YKK80 is one of the lowest energy consuming offices in Japan with verified occupant comfort (Figure 10).

Beyond energy savings and comfort, YKK invites visitors on regular facility tours and uses graphic-based data from their building energy management system (BEMS) to communicate the value of energy and water reduction strategies. Another innovative feature is a state-of-the-art, real-time earthquake detection system designed to provide immediate response and safety information for occupants. The entire building rests on seismic isolation pads.

Operation and Maintenance
Two years of performance verification was included in each team members contract and uses sophisticated BEMS data to support operation and maintenance. The entire team (owner,
Delivering the Energy Savings that Building Owners demand with the comfort that Occupants thrive in

Daikin’s VRV IV systems integrate advanced technology to provide comfort control to help maximize energy efficiency and reliability. VRV IV provides a solution for all types of applications, from multi-family residential to large commercial.
CO2 concentration (ppm)
- avg. 651 ppm
- avg. 408 ppm (outdoor air)
- avg. 707 ppm
- winter season: 2017
- summer season: 2017

YKK HEADQUARTERS

Figure 9
AIR TEMPERATURE AND MRT NECESSARY FOR COMFORT (PMV=0) OF SEDENTARY PERSONS IN SUMMER CLOTHING AT 50% RH

Figure 10
SOURCE ENERGY OF OFFICE BUILDINGS OVER 10,000 M² IN TOKYO (2009)

The final energy results are shown in both Table 1 and Figure 6. These results, when modeled using DOE’s Energy Plus against an ASHRAE/IES Standard 90.1-2007 baseline, demonstrate a 27.5% savings (site energy) and, when comparing actual results to the baseline, they indicate a 32.5% savings (site energy) and indicate a 53% savings (source energy) compared to an average Tokyo regional once building.

Cost Effectiveness
YKK80 used an integrated design process to optimize the whole building as a system and to use single elements, such as the sudare screen or the sloped radiant ceiling panels, for multiple functions. Still, the initial investment was greater than a conventional similar office building.

The increase in the initial (2013) investment was JPY720 million (~USD$7.2 million) or JPY34,418/m² (~USD$32/ft²). The present day utility cost savings are JPY66 million (~USD$630,000) per year, or JPY3,155/m² (~USD$2.8/ft²), which is 52% less than a similar sized Tokyo office building. Using a simple payback analysis, this will require just under 11 years to pay back the additional investment—assuming utility costs do not increase. Even with a modest productivity gain of 5% (much higher increases have been documented in other green office designs).

Table 1
ANNUAL ENERGY PERFORMANCE SUMMARY

<table>
<thead>
<tr>
<th>Source-Site Ratios in Tokyo Japan</th>
<th>Electricity: 2.711</th>
<th>Natural Gas: 1.005</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.1-2007 Baseline</td>
<td>48.71</td>
<td>120.74</td>
</tr>
<tr>
<td>Proposed (modeled)</td>
<td>35.31</td>
<td>91.06</td>
</tr>
<tr>
<td>Actual</td>
<td>32.87</td>
<td>82.08</td>
</tr>
</tbody>
</table>

This information is reported monthly at a commissioning meeting and contributes to ongoing energy-savings and improved occupant comfort.

Figure 11 shows one year of actual monthly operating data as compared to the ASHRAE/IES Standard 90.1-2007 baseline and energy simulation.

Detailed, real-time monitoring of energy and environmental systems (cooling/heating, plumbing systems, water use, electricity, and lighting) is provided by the building automation system (BAS).

designer, contractor, manufacturers, and operators) will participate in this ongoing performance verification until two years after occupancy.
Environmental Impact
The actual reduction in CO₂ emissions is 22.6 kg-CO₂/m² (4.64 lb/ft²) or 32% below the baseline (CO₂ emission factor in Tokyo, electricity: 0.496 kg-CO₂/kWh [1.1 lb-CO₂/kWh]; natural gas: 2.23 kg-CO₂/kWh [4.9 lb-CO₂/kWh]; and tap water: 3.129 kg-CO₂/m³ [0.19534 lb/ft³]). This building also incorporated high-efficiency water-saving equipment (water closets: 3.8 L [1 gallon U.S.] water per flush, faucets with 14-second shut-off timer), and currently consumes 65% less tap water than that of an ordinary office building in Japan. In addition, 100% of the non-tap water necessary for a biofilm process is provided using treated wastewater and reclaimed rainwater.

Social Engagement
YKK understands the importance of being a good corporate citizen and integrating themselves with the local community. Examples of its community engagement include: using outdoor plants (with signage) on its site that have been present in its neighborhood since the Edo period (approximately 1615 to 1868); promoting farm-to-table food using their rooftop garden; and offering local handicraft manufacturers opportunities to hold workshops and exhibition events using the area around the building entrance.

Conclusion
Based on the latest data from Tokyo Metropolitan Government, YKK80 energy performance is in the top 1% of the 465 buildings sampled. Focusing on the initial project goals of energy-savings, comfort, health, seismic safety, and cost-effectiveness through life-cycle design, the YKK80 building has clearly met, and even exceeded these goals—providing a new benchmark for high performance office buildings in Japan.

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