# Apple Store Dubai Mall

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## Introduction

Apple Dubai Mall reinvents the traditional introverted idea of mall-based retail as a more outward looking experience that engages with the spectacle of urban life. Its design is a highly innovative response to the culture and climate of the Emirates, while also demonstrating Apple's pioneering ambition to create inspirational civic spaces for all.

## Culture, Context and Climate

The design of Apple Dubai Mall is a celebration of the sun, using the abundant daylight to create a special ambience within. Reinterpreting the traditional Arabic Mashrabiya, innovative, 'Solar Wings' gently shade the outside terrace during the day and open majestically during the evening to reveal the 'best seat in the house' with a breath-taking view of the waterside promenade and fountains.

Located in Dubai Mall – one of the most visited urban centres in the world, attracting over 80 million visitors every year since 2014 – the new Apple Dubai Mall occupies the most pivotal position in the city, alongside the iconic Burj Khalifa and overlooking the famous Dubai Fountains. Spanning over two floors, it embraces the theatre of the fountains with a sweeping 186-foot (56.6 metre) wide and 18-foot (5.5 metre) deep terrace – a first for any Apple Store – with unparalleled views of the spectacular setting and the incredible choreographed display.

With the store's highly visible location overlooking the Dubai fountain, the aesthetic character of the storefront was clearly important, seeking to match the drama of the nearby fountains and to provide a strong visual connection between inside and outside to draw visitors into the store.

During the summer months, Dubai is subject to intense heat, humidity and insolation. Summertime temperatures can exceed 45°C and the global annual average solar radiation is approximately twice that of London, therefore balancing internal comfort, glare, daylight and energy consumption represents a significant challenge.

The tension between the need for a beautiful South-West facing façade embracing the key view lines, the harshness of the climate and the desire for transparency all combined to set a challenging multi-parametric brief which could only be fully satisfied by a dynamic solution.

The complex interactions between the façade and the environmental systems inside the building required a fully integrated design approach involving Foster + Partners' in-house Specialist Modelling, Environmental Engineering and Structural Engineering Groups working alongside the architectural team.



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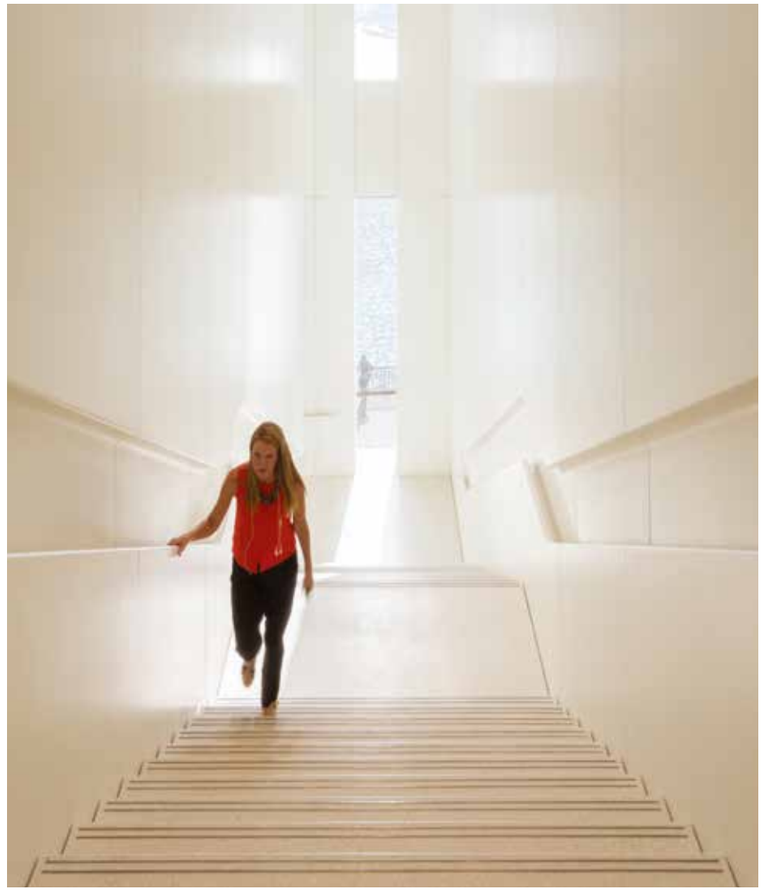

### The Development of the 'Solar Wings'

With their movement path inspired by a falcon spreading its wings, the 'Solar Wings' are a theatrical experience – an integrated vision of kinetic art and engineering. The wings have been carefully crafted to inspire delight, a delicate combination of form and function.

Made entirely of lightweight carbon fibre, each wing has multiple layers of tubes forming a dense net, comprising 340 individual rods with a total length of 900m. Based upon in-depth study of sun angles, the rods are distributed in higher concentration where the solar radiation is the most intense over the year. The unique pattern deliberately allows clear views out for people standing on both levels of the store with the sunlight streaming through the wings casting dappled shadows deep into the interior. The new shaded terrace features nine substantial trees within large planters incorporating seating for visitors to sit, relax and enjoy the view. The planters rotate mechanically to ensure that the trees receive even sunlight and grow symmetrically.

At 3m wide and weighing 1200kg each, the wings are designed to take 1 minute to open or close. However, the prevalence of wind-blown fine sand dust in the UAE meant that the mechanism had to be detailed carefully to reduce the risks of the abrasive particles getting into moving interfaces and causing premature wear in the system. This risk was reduced by minimising the amount of machinery located under the floor.

The objective of the drive system was to provide a mechanism that could move the rearmost part of the panel 5m along a straight track from a retracted to deployed state and vice versa with accurate positional control while also offering rotational guidance. The leading edge of each wing was mounted on a curved track to provide the rotation during the deployment, so the panels rotate through 92° to arrive in a tangential position at the balcony edge. However, the weight limitations on the 12m cantilever structure supporting the roof meant that the preferred method of supporting and driving the panel from above was impossible.

A key breakthrough in the design development came with the elimination of the lower curved tracks on the balcony floor, the area most vulnerable to collecting abrasive debris, significantly reduced the complexity and visual impact. Consequently, only two parallel 6mm



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slots per unit are used to guide the lower carriage running under the floor into position limiting the amount of debris ingress and simplifying the design of the access panels in the terrazzo floor.

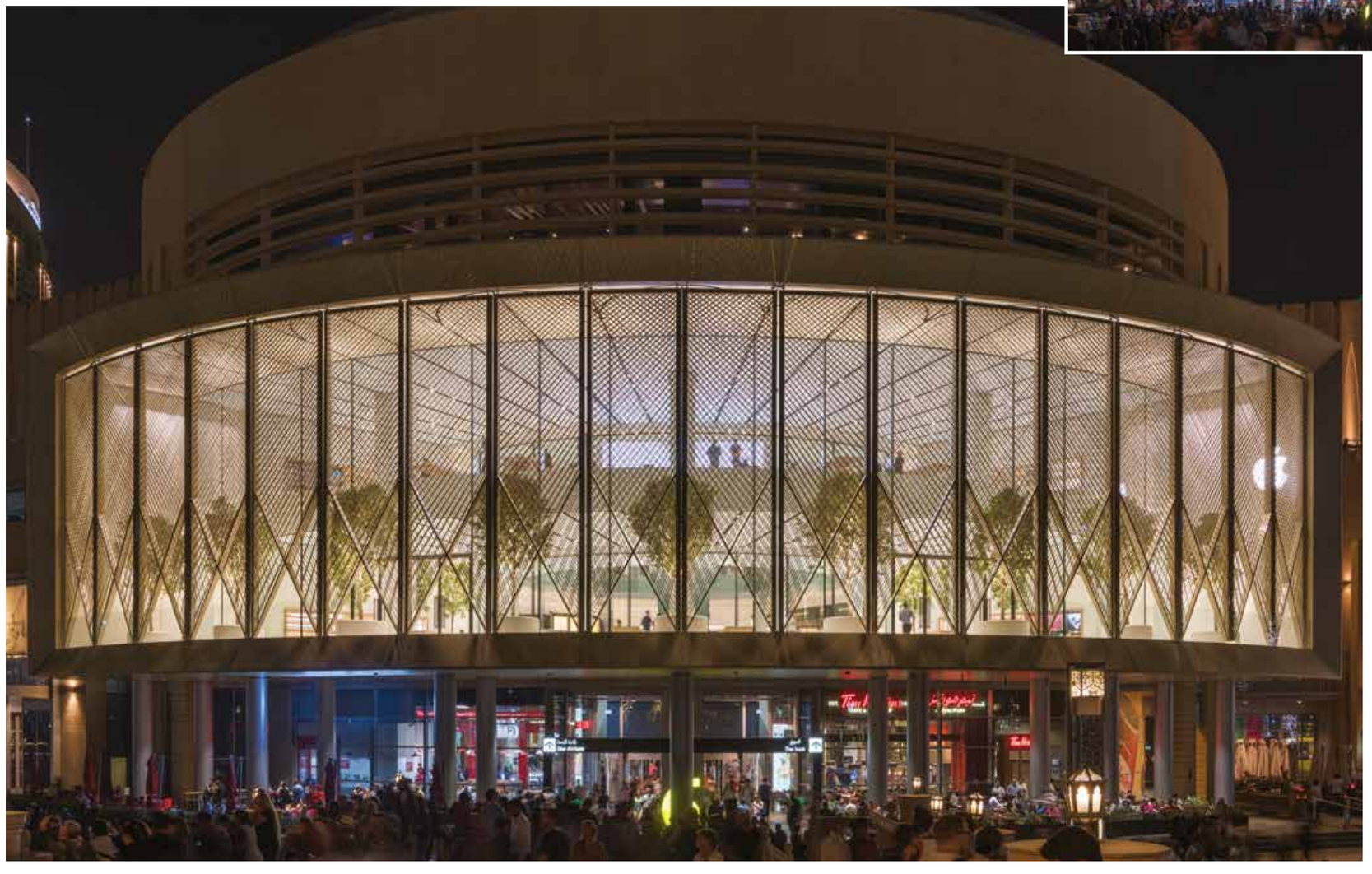
The removal of the curved track requires that the unguided "free legs" need to be locked once the panel is in the deployed or retracted positions. This was achieved by installing an actuated locking system under the floor that drives a lock pin into the underside of the free leg when the panel is parked. Careful detailing of the latching system ensures correct engagement of the pins during all operating conditions

The design also sought to minimise the risk of movements of the cantilevered roof affecting the mechanisation system. This required a combination of low friction thermoplastic bearings pivots and slides to accommodate any structural deflections under load. The locking systems comprise actuated and non-actuated slots to transmit wind loads into the primary structure in both the deployed and retracted positions. This eliminates the need to move the panels into a specific deployed or retracted position in the event of an advancing storm.

### Glass Selection and Specification

The design of the Solar Wings was carefully calibrated, along with the roof overhang, to provide optimal shading during peak solar conditions and reduce the direct solar radiation falling on the glass.

Accordingly, the specification of the glazing is based around the 'effective' g-value of the entire façade system including the 'Solar Wings' rather than just the glass itself. Consequently, a solar coating was not applied to the glass as the combined solar performance of uncoated low iron glass and the shading system significantly exceeded the energy code baseline requirements. Thereby solar heat gains are effectively controlled and daylight is plentiful while views in and out of the store remain uninterrupted when the wings are retracted and parked.

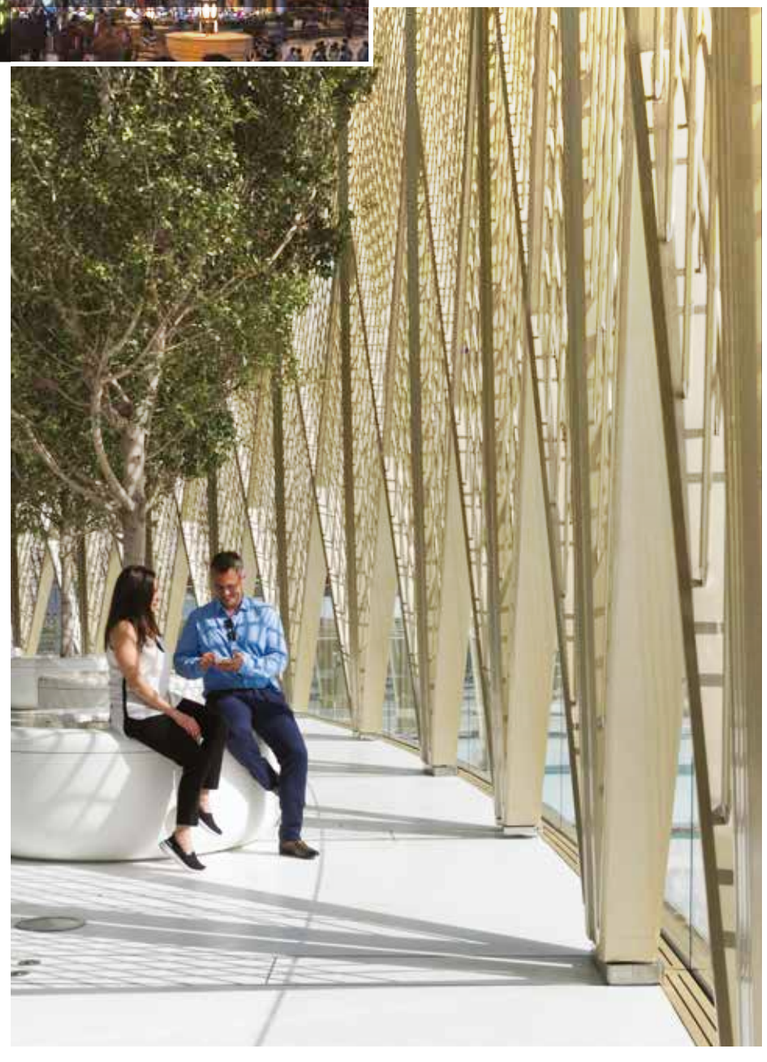






The air temperature differential between inside and outside is significant, however, which could potentially lead to additional cooling demand arising from conduction heat gain plus a risk of condensation forming on the outer surface of the glass during periods of high humidity. This was managed by the specification of an insulated glazing unit (IGU) engineered by Eckersley O'Callaghan, comprising 2+2 sheets of structural glass with an air gap between to limit conduction of heat to manageable levels.

In this way the combination of the glass specification and the Solar Wings effectively controls environmental heat gain to the store.



**Miriam Dall'Igna BArch , BSc , MSc**
Foster + Partners | Associate Partner | Design Systems Analyst
University of Westminster | Faculty of Architecture | Computational Design Professor

Miriam has experience on the design and research of complex structures for manufacturing and construction. Her passion lives in the integration of building physics and structural requirements through geometry and computational methods. Part of her tasks are the experimentation and implementation in architectural practice of state of the art software and hardware. She is currently focusing in the research of goal-oriented autonomous robotic systems, additive manufacturing and adaptive building envelopes for large scale construction in harsh environments. She joined Foster + Partners in 2008 and University of Westminster in 2012. Her background is in architecture and computer science.

**Andrew Jackson MEng (Hons), CEng MCIBSE**
Partner, Senior Environmental Engineer
Visiting Professor of Sustainable Building Design at University of Sheffield

Andrew has worked in engineering design and consultancy since 2005, completing a diverse range of projects across all major sectors and became a chartered engineer in 2011. Since joining Foster + Partners in 2012 he has led the environmental engineering team on projects in various global locations, promoting the integrated design philosophy pioneered by the practice. He is a keen supporter of STEM education having previously been a STEM ambassador. Andrew has also been a visiting professor of Sustainable Building Design at the University of Sheffield, one of four 'centres of excellence' for sustainable building design identified by the Royal Academy of Engineering.

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## Sustainability and Energy Efficiency

Apple's first store in the UAE, also designed by Foster + Partners, was opened at the Mall of the Emirates in October 2015 achieving a LEED Platinum rating and setting a benchmark for sustainability and energy efficiency which Apple Dubai Mall sought to emulate and surpass.

As described above, significant attention was paid to mitigating environmental heat gains through the façade design thereby reducing the associated cooling demand. Internal heat gains in the retail environment are also often significant due to the relatively high occupant density, lighting levels and equipment compared to other building typologies which can generate high cooling demand if not carefully managed. The general lighting at Apple Dubai Mall is provided by highly efficient luminous ceiling panels, comprising a network of tiny LED lights and a reflector above a stretch fabric panel. This system delivers a diffuse ambient light with a similar characteristic to natural daylight. The efficiency of this lighting system ensures that both the energy consumed directly by the lighting is reduced along with the secondary cooling energy arising from the excessive heat typically associated with retail lighting

A further challenge is posed by the store geometry – the height of the sales area is over 5m at the balcony level and over 4m at the mezzanine level – which creates a large volume to be conditioned. Extensive Computational Fluid Dynamics (CFD) simulations of air movement were undertaken to optimise the placement and discharge velocity of air supply points to condition the occupied zone only, allowing the temperature in the unoccupied high-level stratified zone to drift upwards.

To take full advantage of the Solar Wings and the CFD analysis the conditioning systems are designed around 'felt' temperature metrics which incorporate effects of radiant temperature and air movement in addition to air temperature. This allowed the internal air temperature set point to be adjusted to realise energy savings whilst offering improved thermal comfort. The design of the ventilation and cooling systems also decouples the treatment of outside air from the space conditioning to improve efficiency and employs a total energy recovery system to transfer unwanted heat and moisture from the incoming fresh air to the outgoing air stream before employing any mechanical cooling. Given the scarcity of water in Dubai minimising use of potable water is essential, accordingly any residual condensate arising from dehumidification of fresh air is collected and fed back into the site-wide condensate recovery system.

## The Role of the Facade

The contribution of the façade to the visual character of this project is immediately apparent at first glance. However, it also sits at the nexus of the climate, the culture, the context and performance of this project interacting with the active building systems and fundamentally influencing the occupant experience. A truly integrated piece of design.