Malaysia's Construction Marvels in 60 Years of Merdeka










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Contents

Preface

In this book we endeavour to capture the magnificence of Malaysian iconic projects built in the 60 years after Merdeka. We specifically sought to feature buildings and infrastructures which are very unique aesthetically and play a significant role in the socio-economic development of the country.

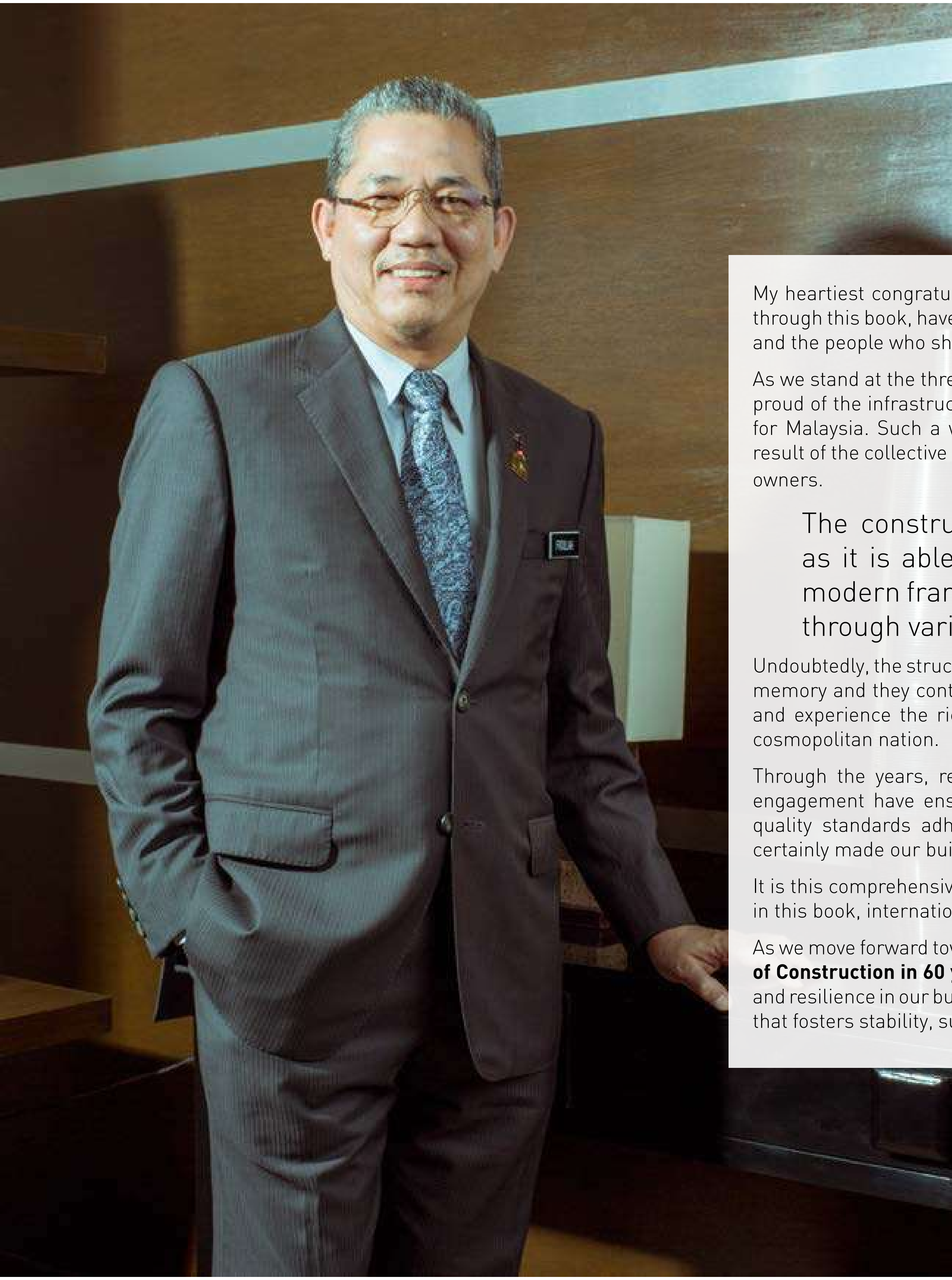
We started with a much longer list, but tracking down the information we need, from individuals who have played a key role in the development of these projects had proven to be an arduous task. In some cases, our repeated requests had not received any response at all.

As such, this body of work is by no means exhaustive. Our appreciation goes to those individuals who did respond to our queries and came forward with useful insights on these iconic projects. We accord our appreciation for all those who have worked with us in bringing this book to fruition.

This book is truly dedicated to those who payed a role in the planning, designing and building of these construction marvels. We believe that the stories behind these iconic structures will surely inspire the new generations of designers and builders to give birth to even greater structures that the nation will be proud of in the future.

Thank you.

The Editorial Team



Foreword by
Yang Berhormat Dato' Sri Haji Fadillah Yusof Minister of Works, Malaysia

My heartiest congratulations to the Construction Industry Development Board (CIDB) who through this book, have showcased the icons created by industry players, builders, architects and the people who shape the physical built environment we see and experience around us.

As we stand at the threshold of becoming a developed nation, we can look around us and be proud of the infrastructure and construction marvels that have become beacons of identity for Malaysia. Such a world-class built environment did not happen by chance – it is the result of the collective efforts of our developers, architects, builders, engineers and property owners.

> The construction industry is one that is indeed unique as it is able to lend both a historical perspective and a modern frame of reference in capturing a nation's journey through various periods of development.

Undoubtedly, the structures in this book have established their place in the nation's collective memory and they continue to invite people – visitors and Malaysians alike – to learn about and experience the richness, diversity and talents of people who have built this thriving cosmopolitan nation.

Through the years, regulators, policy makers and other key stakeholders in concerted engagement have ensured that each phase of development has seen higher safety and quality standards adhered to. The resources and capabilities that we have today have certainly made our buildings sustainable, healthier and less carbon invasive.

It is this comprehensive body of knowledge that has won many of the structures showcased in this book, international recognition and accolades.

As we move forward towards a developed nation status, let us learn from **Malaysia's Marvels of Construction in 60 years of Merdeka** to continue the tradition of ensuring sustainability and resilience in our built environment sector and further create a landscape of infrastructure that fosters stability, supports economic growth and meets the evolving needs of the people.

Foreword by
Yang Berbahagia Tan Sri Dr. Ir. Ahmad Tajuddin Ali, Fasc. Chairman of CIDB Malaysia

It gives me great pleasure to present this coffee table book that showcases **Malaysia's Construction Marvels in 60 Years of Merdeka**. This book is a compilation of evocative structures and buildings that showcases our nation's passage through history and brings to the fore our capabilities and capacity for building new generation structures.

> Each of the construction marvels chosen in this book demonstrates stories of heritage and looks at contemporary and modern spaces constructed to propel Malaysia into a new era.

This book also provides insight into the ingenuity and creativity of design and construction techniques which have won international awards and accolades. Through these structures, the reader will derive a sense of evolution moving from buildings constructed in the 1800s to architecturally intelligent structures conceived and built for the needs of the 21st century.

As the industry's regulator, CIDB has set the standards, placed emphasis on professionalism and regulated the construction industry for more than 20 years now. Ensuring quality, accreditation and capacity building for professionals in the industry has promoted a culture, within industry professionals, to abide and adhere to internationally recognised standards. Today, we are proud that some of our nation's best have gone beyond the boundaries to build in the global arena.

To the builders, designers, architects and construction companies who have all played a significant role in bringing these marvels of construction to fruition, thank you.

We hope this will serve as a showcase of the breadth and depth of your talents for buildings and structures that have stood the test of time and will continue to be landmarks for generations to come.

Foreword by
Yang Berbahagia Dato' Ir. Ahmad 'Asri Abdul Hamid Chief Executive of CIDB Malaysia

On behalf of The Construction Industry Development Board of Malaysia, I am delighted to see this book come to fruition to showcase Malaysia's marvels of constructions.

The construction industry plays a pivotal role in shaping the urban landscape,infusing a nation with identity, culture and character. Not only does it design how the urban spaces look, it also fuels economic growth and enhances environmental sustainability.

Looking at the historical development of infrastructure through the years, imbues us with a sense of pride on how builders even as early as the 1800s could design and develop buildings with a green philosophy.

As technology advances, we see how infrastructure moved with urban transformation and responded to needs such as the Sepang Circuit which brought an economic boon and the SMART Tunnel which responded to a necessity for flood mitigation.

> This book celebrates the historical and the contemporary and educates on how constructions and buildings play an important role as catalysts for renewal and re-appropriation of urban spaces.

As CIDB continually looks at transforming and developing the construction industry, we forsee many more marvels that will establish a visual spread of infrastructure for Malaysia to celebrate.







"Undoubtedly, the structures in this book have established their place in the nation's collective memory and they continue to invite people – visitors and Malaysians alike – to learn about and experience the richness, diversity and talents of people who have built this thriving cosmopolitan nation"

- Yang Berhormat Dato' Sri Haji Fadillah Yusof-

Minister of Works, Malaysia

Express Rail Link (ERL)

Despite the challenges it faced during a tumultuous economic climate, solid partnership and collaboration with parties that have the technical expertise helped the ERL project charge ahead. It continues to move ahead into the future, providing a world class, award winning rail service that is fast, efficient, safe, reliable and hassle free between the city of Kuala Lumpur and the Kuala Lumpur International Airport.

The idea for an express rail link from the Kuala Lumpur International Airport (KLIA) to the city centre was first mooted in the early 1990s, years before KLIA and the Kuala Lumpur City Airport Terminal (KL CAT) in Kuala Lumpur (KL) Sentral began operations.

The ERL was set up with the vision of being an internationally acclaimed rail service, providing a seamless experience that is fast, reliable, comfortable and convenient.

One of the key challenges when KLIA was built was its distance from the city, and despite good infrastructure like purpose built roads and expressways, the journey would still take about 50 minutes from the city and even longer in heavy traffic.

Thus, a high speed rail link was a logical solution. The proposal for this link between KLIA and KL city's transport hub was put forward by YTL Corporation Bhd.

It was initially met with apprehension by the government due to the high estimated ticket prices of up to RM200 per journey. That made it impractical.

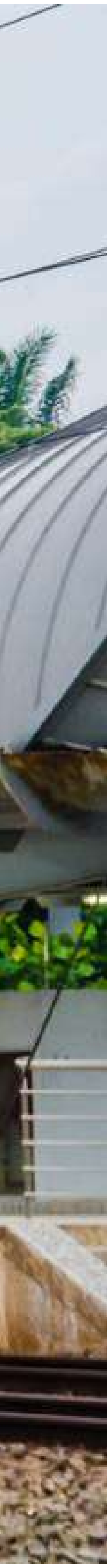
However, in 1995, the Malaysian government called for bids following new proposals with much lower travel fare.

Following this, Express Rail Link Sdn Bhd (ERL) was awarded the concession on 25 August 1997 to finance, design, construct, operate and maintain the KLIA Ekspres, KLIA Transit and other ancillary activities related to railway services for 30 years.

It also stipulated starting fares at RM35, with scheduled increases over time.

The agreement, signed in 1997, also provides the option of extending the 30-year concession for another three decades.

The ERL station in Salak Tinggi has a unique design symbolizing soundwaves



ERL's current shareholders are YTL Corporation Berhad, Lembaga Tabung Haji, SIPP Rail Sdn Bhd and Trisilco Equity Sdn Bhd with 45%, 36%, 10% and 9% shareholding respectively.

Globally recognised, Siemens AG and YTL established SYZ consortium to undertake turnkey construction of the entire project. Siemens is the leading manufacturer of trains in Germany, and one of the leading international suppliers to the railway industry. The company also has extensive project management experience.

In 1999, ERL Maintenance Support Sdn Bhd (E-MAS) was set up – a joint venture between ERL and Siemens AG, manufacturer of the trains. While ERL's focus is on passengers, E-MAS looks after maintenance of KLIA Ekspres (between KL City Airport Terminal and KLIA) and KLIA Transit that stops at three intermediate stations at Bandar Tasik Selatan, Putrajaya & Cyberjaya and Salak Tinggi.

E-MAS manages two separate services on one alignment, 12 trains, five stations, a warehouse with tens of thousands of parts, a substation, high-voltage electrical cables, wild animals and intruders on the tracks, floods, lightning, vandalism, lost and found items and millions of passengers.

Ultimately, this was a venture that would put in place channels for technological transfer over time. In 2005, ERL took over as sole owner of E-MAS.

The KLIA Ekspres commenced operation on 14 April 2002 as a non-stop 57km air-rail connection between KLIA and KL Sentral Station, with a journey time of 28 minutes.

Passengers can now also take a 3-minute ride between KLIA and KLIA2, the low-cost carrier terminal. The trains run four services per hour during peak hours, and three services per hour during off-peak hours.

The KLIA Ekspres train is capable of accelerating at 1 meter per second while maintaining inside noise levels of 78dB. It cruises at a maximum operational speed of 160km per hour - the fastest train speed in Malaysia. In the event of an emergency, the train is able to produce a combined deceleration of -1.3 meter per second.

The trains run on two-track standard gauge main line railway, which allows for wider trains with greater stability. Some parts of this service in the city runs on existing Keretapi Tanah Melayu Berhad (KTMB) lines.

This project is the biggest civil engineering project for YTL, and it involved major transfer of technology from German experts to locals. The track works are in accordance to German standards, and rail components imported from Germany.

The line throughout is continuously welded to provide a smooth and comfortable experience. Service started with 12 sets of 4-car trains, and the number of sets and cars will be added over time.

The design philosophy of the stations fuses Malaysian culture with technology. The organic 'winding' pattern carries the 'Airport in the Forest and Forest in the Airport' design throughout the line.

The multi coloured geometric floor pattern is based on a weave concept that is reflective of Malaysian handicraft and its multi-racial society. It is also thoughtfully planned out to be traveller friendly and easily accessible to those with special needs.

Instead of the usual blues and greys, the air-conditioned cars were given a splash of unconventional nouveau colours like purple, yellow and green to brighten up the interiors which were manufactured with durable fabric of international standard.

The trains are also equipped with shaded windows, ergonomically designed seats, floor carpeting, facilities like toilets for physically challenged passengers, luggage racks, overhead racks and a secure dedicated container baggage area for check-in and check-out baggage.

The 1,300mm-wide opening doors on the trains are fully automated and are of bi-parting sliding plug type, complete with retractable steps for easy access.

The continuous gangway along the entire length of the train, ensures an unobscured view, spaciousness as well as safety.

The ERL project was undertaken during a time when Malaysia was faced with one of the most challenging periods in its history.

This project was among many others that were hit hard by the Asian Financial Crisis in the late 1980s and early 1990s, but despite this it was completed in a record time of 32 months.

Following several setbacks, Kreditanstalt fur Wiederaufbau, acting as lead arranger for the export credit facility, Bayerische Hypo und Vereinsbank, Dresdner Bank and Bank Gesellschaft Berlin came together to disburse a total loan of 655 million Deutsche Marks to finance the works portion. The Ringgit portion of the financing, mainly for civil works was extended by Bank Pembangunan dan Infrastruktur Malaysia Bhd.

The operation control centre and maintenance depot are located at Salak Tinggi. This includes CCTV monitoring of trains, station concourses, platforms, baggage handling areas and depot areas among others.

The ERL offers comfortable ergonomically designed seats with ample space for luggage

The challenge that took up most time was liaising with third parties who owned land along the line, in addition to finding the best solutions to cut through live railway systems, roads and highways. This was overcome with assistance from the various government departments and agencies that expedited the necessary processes and approvals to resolve the issues at hand.

The climate and predominantly clay soil which is prone to erosion, were among other challenges faced and these had to be overcome within a tight time frame. The successful partnership and good overall coordination between stakeholders saw this through.

ERL has been recognised locally and internationally for consistently providing high standards in the air-rail services industry. ERL received the ISO9001:2008 certification for Quality Management System while E-MAS was awarded the ISO14001:2004 certification for Environmental Management System.

ERL has also received numerous awards at the prestigious ***Global Air-Rail Awards***, namely:

- Best Customer Service Award for KLIA Ekspres VIP Service (2011)
- Personality of the Year for Noormah Mohd Noor, Chief Executive Officer of ERL (2011)
- AirRail Link of the Year (2012)
- Environmental Commitment (2013)
- AirRail Link of the Year (2014)
- AirRail Link of the Year (2015)
- Marketing Campaign of the Year for KLIA2 Service Launch (2015)
- AirRail Link of the Year (2016)
- Social Responsibility Award for Frog Classroom Makeover Programme (2016)

On the home front, ERL received the Best Operator Award in the Intercity and Urban Rail category at the LPT Symposium 2014. It won the Best Safety Practices Award and Best Customer Service Award at the LPT Symposium 2016. ERL was recently awarded the Outstanding Green Air-Rail Transport Award in conjunction with Malaysia Canada Business Council's 25th Anniversary Business Excellence Awards 2017 in May.

To date, ERL has carried more than 80 million passengers

It recently ordered six new train-sets from CRRC Changchun Railway Vehicles Company Limited (CRRC Changchun). ERL's total capacity will gradually increase by fifty percent when the trains start operating from Q4 2017 ■

At a maximum commercial speed of 160 km/h, the ERL offers the fastest speed for rail travel in Malaysia

Federal Territory Mosque

A Stately Place of Worship

The Federal Territory mosque features a unique blend of local Malay and Middle Eastern architecture and provides a serene and tranquil spot for prayer, solace and reflection for busy Kuala Lumpur city dwellers.

The Federal Territory mosque located near the government and court complexes on Jalan Duta, Kuala Lumpur was built for the Federal Territories Islamic Department (JAWI). In addition to being a place of worship for civil servants and city dwellers in the area, this mosque, with its unique design and architecture appears to break the monotony of the concrete jungle around it.

The Public Works Department commenced construction on this iconic structure on March 15, 1996. Work on the 13.4ha site was completed on August 30, 2000 and the building was handed over to JAWI the following month.

The Federal Territory mosque was the brainchild of Malaysia's fourth Prime Minister Tun Dr Mahathir Mohamad who conceptualised the design and architecture for this state mosque that was commissioned by JAWI.

It is designed to function as a comfortable place for worship, a place for knowledge and learning, a place for social and welfare services, and an education facility, in addition to being a spot for fellowship and reflection for city dwellers. The 47,000 sq ft mosque can accommodate a total 17,000 faithful at any one time.

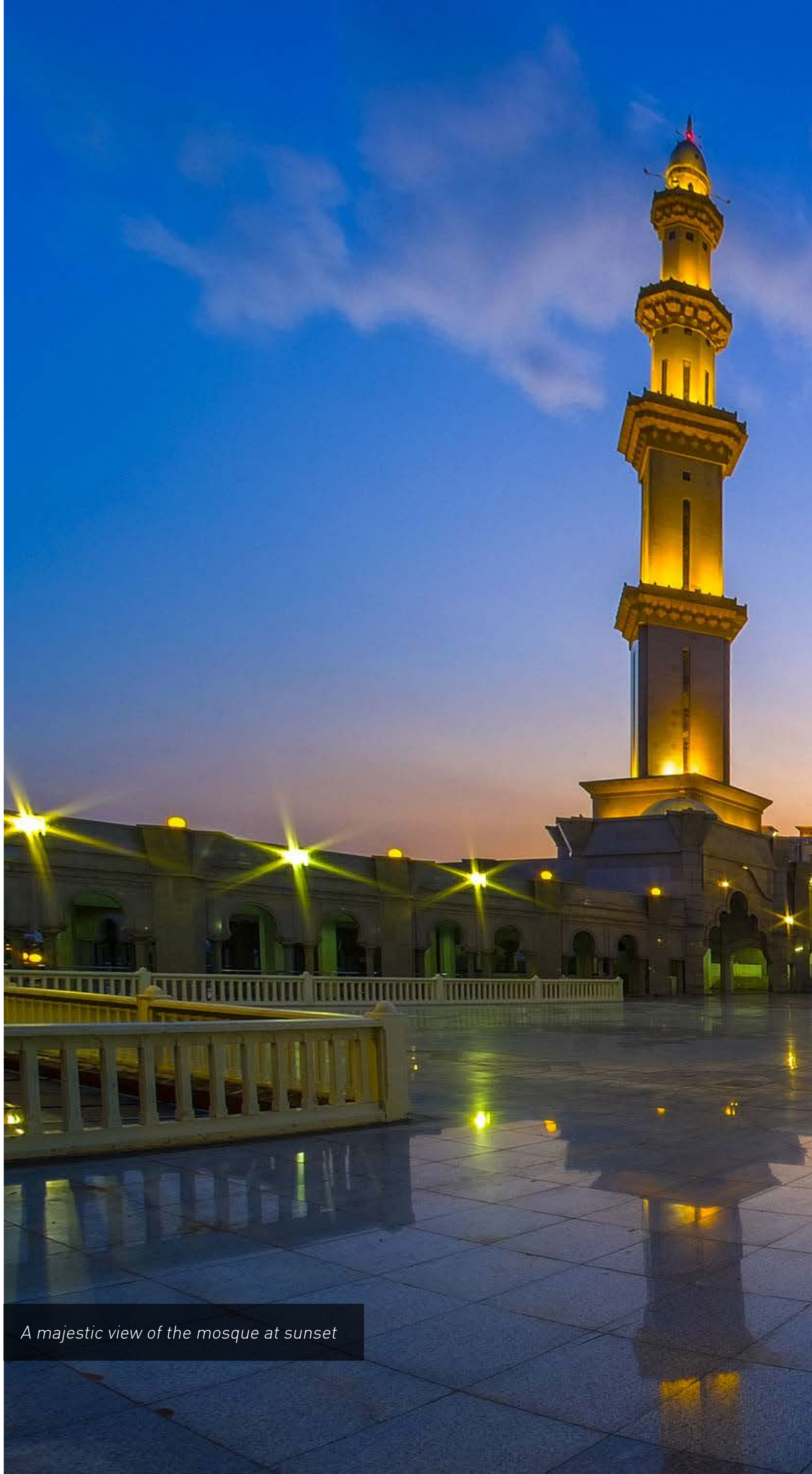
Officiated by then Yang Di-Pertuan Agong Tuanku Syed Sirajudin Ibni Almarhum Tuanku Syed Putra Jamalulail on February 18, 2005, the design of this mosque employs the concept of a place of worship within a park, and blends traditional 16th century Turkish Ottoman mosque styles with local Malay design and architecture. The interior of the mosque amalgamates Malay, Indian, Moroccan, Turkish and Iranian designs.

A blend of different construction materials including marble, granite, glass fibre epoxy resin, etched glass, stained glass, white gypsum, ceramic and mosaic tiles were used for this mosque. In addition, exotic semi-precious stones such as lapis lazuli, onyx, golden onyx, red and golden jasper, mother of pearly and malachite adds into the list of construction materials.

One of the main features of this mosque is the 45m high primary dome which has a diameter of 30m, just above the main prayer hall that is made from a composite material of glass fibre and epoxy resin- making it light and durable. This main dome is flanked by smaller domes and half domes, and there are a total 22 domes in this mosque altogether.

The main prayer hall taps into the design of many great mosques and features clean cut lines and white marble that symbolises purity, while intricate wood carvings and screens adorn the *minbar* and separate prayer areas for men and women.

Intricate carvings on marble and wood also adorn the walls and ceilings. The carvings on marble were done by craftsmen from India with inlay technique used to form the arabesque pattern.



A majestic view of the mosque at sunset

Wood carving motifs in the Federal Territory mosque are based on the traditional Malay 'awanlarat' design that reflects nature.

The wood carving designs of this mosque also incorporates the forms of fragrant flowers - the bunga tikam seladang, bunga mas, cempaka, kenanga, tanjung, melur and also curvy ferns.These carvings and designs were created by local artisans from the states of Kelantan and Terengganu.

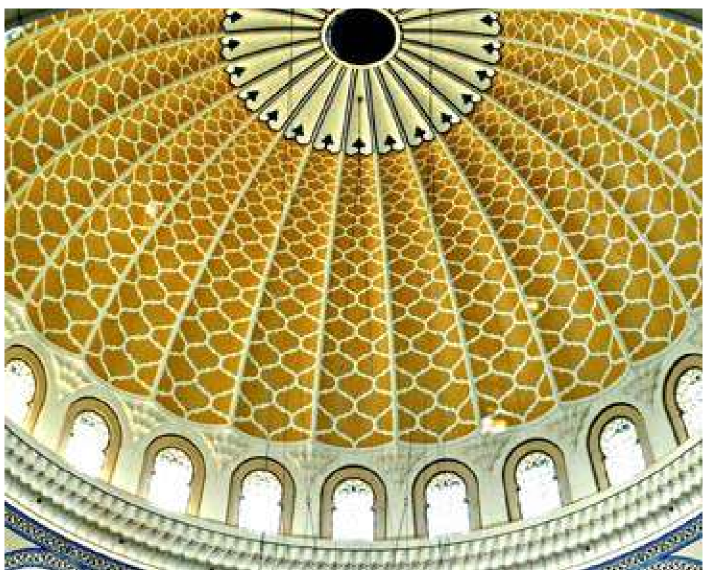
The main prayer area and multipurpose hall are air-conditioned and equipped with lifts and escalators connecting the floors above.

A half-dome concave with hand carved details in the front of the prayer hall acts as an amplifier when prayers are recited or called by the imam, while an open area in the middle of the mosque dubbed '*Laman Hidayah*' is designed as a space for fellowship, and an additional prayer space for devotees when required.

Lighting in the mosque is designed to highlight and accentuate the beautiful architecture in addition to brightening the interiors of the building.

The 'chandelier' in the main prayer hall has a modern and exclusive design that is especially striking at night. It is made from an array of precision cut glass prisms with metal frame, designed to reflect natural and artificial light to the space below.

Stone carvings on the soaring portal arch that leads into the main prayer hall and mihrab are made of marble from Makarana and Jaipur in Rajastan, and Agra in Uttar Pradesh, India. The stones were carved and intricately inlaid with semi-precious stones by Indian artisans. The portal arch was installed by a local construction team before Indian artisans applied finishing touches to the carvings.


The mosque marries Malay, Indian, Moroccan, Turkish and Iranian designs

The use of semi-precious stones such as lapis lazuli, black onyx, malachite, red and golden jasper, mother of pearl and tiger eye add a touch of luxury and gives the mosque an exotic feel, while Thuluth style calligraphy adorn prominent sections of the mosque to be recited and appreciated by visitors and the faithful.

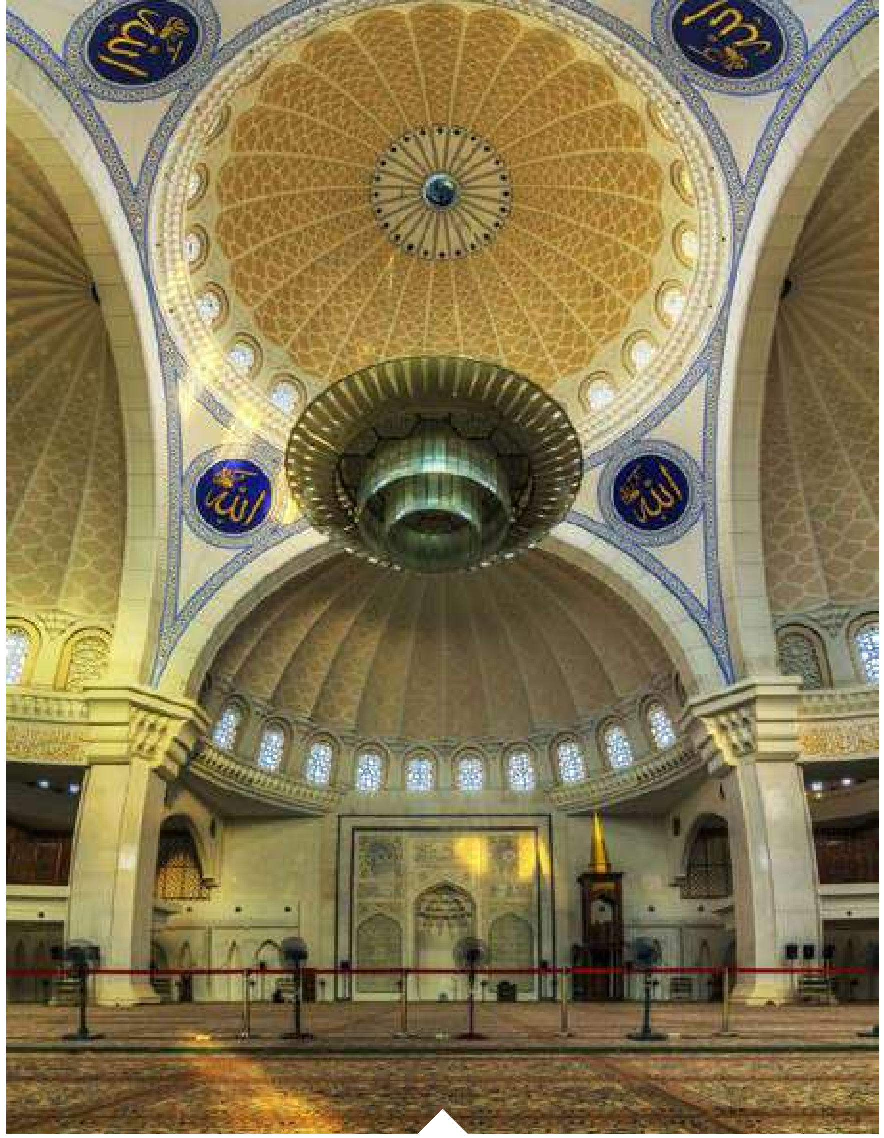
The mosque is encircled by a moat that features cascading water, an element that represents physical and spiritual purification.

One of the main features of this mosque are areas for rest and rejuvenation within it. Pebbles adorn the pathway around a pool, which incorporate seven fountains and a waterfall that gives the mosque compound a peaceful and serene atmosphere. Bio-filters have been installed to ensure that the water in the pool is always clean and clear.

The Islamic garden inspired landscape around the mosque with an array of flora provides a space for building knowledge, reflection and recreation. The garden around the mosque is also designed to lend some balance and harmony to the development that surrounds it.

The garden is divided into three sections, each with its own function and purpose. One section gives visitors a forest experience; the second one provides a recreation spot and the third area - a herb garden signifying a place for healing and rejuvenation.

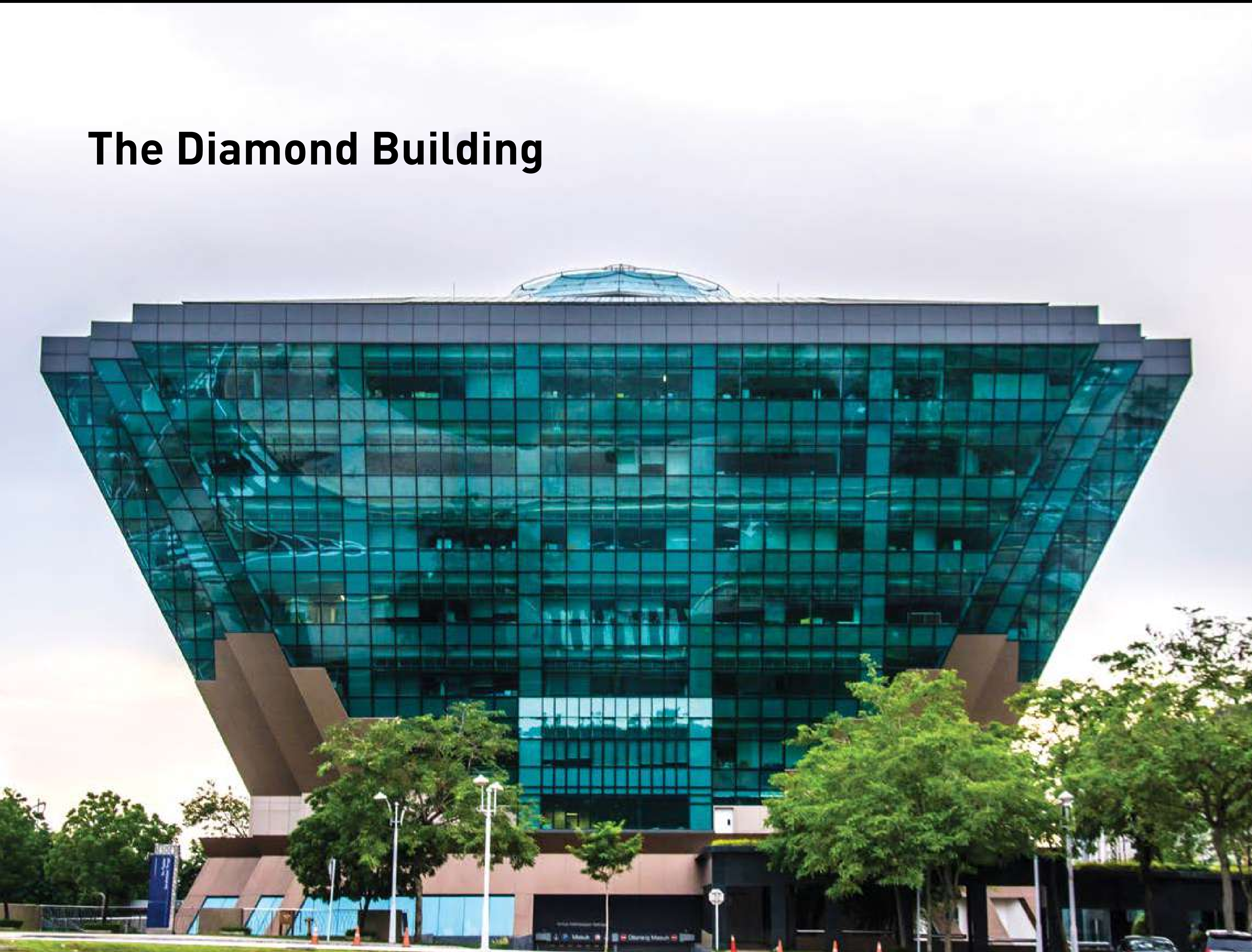
Together, the main building with its exotic architecture, the soothing water features and the recreational garden are interconnected in a manner in which it gives devotees and visitors a sense of calm, coherence and serenity - a perfect place for prayer, reflection and solace in a bustling city centre ■



These half-dome concave with hand-crafted details acts as amplifier when prayers are recited

The turquoise coloured pool surrounding the mosque adds to its grandeur

The Diamond Building



When the Energy Commission of Malaysia, the country's regulatory body for energy policies, standards and safety embarked on building its own headquarters in Putrajaya in 2005, energy efficiency was unsurprisingly a top priority, in addition to going green.

The diamond shaped building symbolises transparency, value and durability, characteristics that represent the Energy Commission's role and mission as a regulatory body. The building takes on an optimal design approach to achieve energy efficiency.

The design strategy encapsulates four main aspects - energy efficiency, water efficiency, indoor environment quality and environmental protection.

The building is also designed to showcase technologies that reduce energy and water consumption, use sustainable building materials and provide enhanced indoor environmental quality.

These include self-shading façades, daylighting, floor slab radiant cooling, suitable landscaping, and mechanical and electrical systems that are suitable for the hot and humid Malaysian climate.

The radiant cooling slabs have chilled water pipes embedded in the concrete slab. This is complemented with the conventional cold air supply system.

The highest heat capacity of the building rests in the concrete mass, thus the direct cooling of the concrete slabs with the embedded water pipes is one of the most efficient means to cool the building.

The air ventilation rate is therefore reduced. This in turn reduces noise from the ducts and improves acoustic comfort significantly.

Extensive computer simulation of the building's diamond form was conducted in the design stages to ensure well distributed daylight for the building occupant's visual comfort.

This simulation also yielded useful information on optimising energy performance and reducing energy consumption without compromising on comfort and functionality.

The Building Energy Index (BEI) is the measurement of total energy used in a building divided by the floor area in square meters.

This Diamond Building is designed with a BEI of 85kWh/m2 per year - a 65% reduction of energy consumption when compared to the average 210kWh/m2 BEI of typical Malaysian buildings.

The diamond dome crowns this building providing ample skylight

The building takes into account details like the integration of mechanical and electrical systems to the building's automation system.

Passive features like the tilting facade of the building allows self-shading for the lower floors, protection from direct sunlight and a smaller building footprint.

In addition, the building orientation which takes into account the solar path, minimizes areas hit by direct sunlight.

This design also provides a larger area for landscaping. The sunken garden at the basement serves as a void space that provides natural ventilation to the basement level car park.

Active features of the building include the use of photovoltaics (PV), daylighting and insulated concrete roofing.

The building is installed with thin film telluride module type PV having a total installed capacity of 71.4kWp, fed directly to the national grid.

Approximately 10% of the diamond building's energy needs are covered by the total capacity produced by the PV.

The estimated electricity generated is 102,000kWh per year - equivalent to RM40,000 in annual savings. This also prevents 63,000kg of carbon dioxide emission annually.

About 50% of this building's lighting is natural. The 'diamond dome' skylight that crowns this building is made from laminated tempered glass.

"Movable automated" blinds that filter and diffuse daylight to prevent glare,and even out lighting for offices in the atrium, are located within the dome.

The windows deeper into the atrium are larger to cater for lower daylight levels. In addition to this Tannenbaum reflective panels were incorporated into the atrium for optimised daylight utilisation

Low-e glazing was installed for the glass facade. This prevents heat gain from the sun by making the facade reflective from the outside, while allowing daylight.

The building orientation takes into account the solar path to minimize areas hit by direct sunlight

Split window design for the exterior facades, supported with an internal light shelf helps redirect natural light into deep work spaces.

Energy efficient T5 fluorescent tubes are used throughout the diamond building instead of the conventional T8 type.

These are integrated with sensors that shut off artificial lighting whenever daylight is adequate, ensuring energy savings.

The roof design allows sufficient daylight to illuminate the seventh floor lounge area.

Insulated boards with a thickness of 100 mm covers the concrete rooftop vertically and horizontally to reduce heat absorption.

This energy efficient building also takes into account water conservation via rain water harvesting for toilet flushing, the use of efficient water fittings such as dual flushing systems, waterless urinals and taps equipped with aerators to reduce potable water usage by more than 65%.

In addition grey water, collected from wash basins are used to irrigate the wetland at the ground floor.

The Diamond Building is designed to provide a healthy and productive work environment for its occupants.

Green labelled plasterboards, made from 30% recycled content, low in Volatile Organic Compound (VOC) emission were used for the ceiling and internal partitions.


Suruhanjaya Tenaga

The carpets are also low in VOC and are made up of 10% recycled content.

The interior paint used for this building has low VOC content.

In addition, workstations in the building were designed to provide protection against Ultra Violet (UV) rays.

Environmental protection is also incorporated into the building design and operations with usage of recycled components which makes up at least 30% of the total project value.

Waste disposal in the building prioritises and promotes recycling, with allocated bins and regular collection by recycling companies appointed by the local authority.

Green vehicles are allocated with reserved parking, while bicycle racks and showers are provided to encourage building occupants to cycle rather than drive to work.

The annual energy savings from this building is 2,029MWh/year or 1,388 tonnes of CO2 per year.

The Diamond Building has been awarded the ASEAN Energy Awards 2012 for Energy Efficient Building - New and Existing Category, Platinum Certificates for meeting the standard of the Malaysian Green Building Index (GBI), the Singapore BCA Green Mark and the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST) ■

Kuala Lumpur International Airport

KLIA: Functionality over Form

The Kuala Lumpur International Airport (KLIA) was designed with prime focus on its functionality over form. This gateway showcases the country's rich biodiversity with its 'Airport in the Forest, Forest in the Airport Concept,' and has bagged many prestigious awards and accolades over the last two decades.

While many iconic projects in Malaysia are known for their unique and innovative architecture blending local and modern designs, focus on the form and design of the Kuala Lumpur International Airport (KLIA) played second fiddle to functionality.

The key focus during design and construction was on the basic functions of the airport. Thus the design had to start from the inside and work its way out.

For KLIA, the volume of passenger and air traffic, the space and capacity of floor spaces and walkways, and adherence to international standards and requirements took priority over design.

That meant dealing with airport planners who had to simulate check-in queues, domestic flight and passenger traffic, international flight and passenger traffic, transit passenger hubs and baggage movement among others.

The structure of the building allows for very wide interior spaces

Only after the layout for this was completed did architects start with the exterior design.

The Public Works Department's (PWD), under the Works Ministry, came up with a Requirements Capture after consultation with stakeholders in the project.

This included Malaysia Airports Berhad (now Malaysia Airports Holdings Berhad), airline operators, the Department of Civil Aviation (DCA) and air traffic control, the Police, and Immigration Department.

There are many constraints that come with building an airport, and mitigating these constraints required a lot of coordination between the stakeholders.

After all the issues had been ironed out and the constraints resolved, a list of 'must-haves' for the functionality of the airport, and a list of 'nice-to-have' frills were drawn up.

KLIA was designed as a transit hub in addition to being an origin-destination. However at the time it was being built, there was little confidence in the airport's ability to compete with Changi Airport in Singapore because of Malaysia's closed sky policy to protect the national carrier Malaysia Airlines. This policy was later shelved.

KLIA was designed to accommodate 100 million passengers per annum. However peak hour passenger load, based on airline scheduling and so on, would be the main consideration for airport designers over per annum passenger load.

Work at the site commenced in 1993 and took about two and a half year to complete, followed by a three year construction period.

The airport was completed way ahead of the six year target in time for the Commonwealth Games in 1998.

The 10km by 10km site surrounded by plantations in Sepang, 70km from Kuala Lumpur was chosen for its potential for future expansion. The aim was to avoid the restrictions that thwarted Subang Airport's expansion. Development along the boundaries of that airport impeded plans to extend the airport and build a second runway.

The site chosen for the construction of KLIA was a greenfield – no power, no water supply and no telecommunications.

It was a challenge to transport heavy loads through the access roads leading to the site located in an oil palm plantation.

Approach roads to the site had to be widened, and bridges strengthened to allow heavy construction vehicles to pass through.

For civil and geo technical engineers, the type of soil at the site posed a challenge.

The roof of the KLIA incorporates the Islamic geometric style and rainforest concept which allows sunlight in between the huge panels

It is close to the Sepang coast line, and comprised of soft clay and peat, thus building and reinforcing the foundation was a challenge so as not to face any problems with soil settlement later.

There were two geo-technical solutions towards this. The first option was a time-dependent solution which required surcharging of the original ground, waiting for a period of time and then removing the surcharge so that the settlement can be complete. This was however time consuming and likely to delay the project.

In lieu of that, the contractors decided it was best to adapt a brute force method by removing all the soft soil, and replacing it with compacted cellulite material.

This has endured till present times without any problems.

In terms of sustainability, when the master plan was drawn up, it included five runways. These runways and the parking apron were connected to the main terminal that was designed to accommodate 100 million passengers per annum.

The sustainability of KLIA was measured in terms of the land mass acquired and advanced planning. In the long term, there is no need to move to another site as the master plan incorporates future expansion.

The 100 million passengers per annum capacity is based on advanced future planning to be achieved in stages.

The first phase target was 25 million passengers per annum and second phase - 45 million passengers per annum. Many felt that the 100 million passengers per annum figure was far-fetched, but KLIA has passed the halfway mark and is currently catering for about 65 million passengers.

When KLIA was being constructed more than 20 years ago, sustainability was not part of the construction vocabulary; there was no emphasis on 'Green Building'.

However, KLIA's design does feature a 'forest in the airport, airport in the forest' concept which includes natural lighting and wide spaces with green areas in between.

This required careful planning. Trees planted in the airport had to be that which don't bear fruits, so as not to attract birds that can be detrimental to plane engines.

Local experts from the Forest Research Institute Malaysia (FRIM) were engaged to transport the trees and re-plant these in the correct solar orientation.

In terms of environmental sustainability, KLIA incorporates water recycling plants, district cooling centres, and designs that take into account power and energy saving functions.

Wastewater from the building is channeled to a treatment plant to be recycled.

Once recycled, this non-potable water will be used to water plants and for toilet use.

The forest in the airport was created by local experts from the Forest Research Institute of Malaysia (FRIM)

KLIA designer Dr Kisho Kurokawa also incorporated energy saving features where air-conditioning vents for the building are installed on the side (where there are circular columns), instead of above the high ceilings.

More energy will be required to cool the building if the air-conditioning blowers were placed above the ceilings because hot air rises to the top.

A district cooling centre within the building was also incorporated into the design. Its function is to produce chilled water and at the same time generate electricity that goes back to the grid.

KLIA's commitment to promote environmental responsibility for all local and foreign travellers was recognised by Green Globe, making it the first and only airport in the world to receive the Green Globe 21 certificate in year 2004 and onwards. In 2012, KLIA was awarded the Platinum status in EarthCheck Benchmarked Airport global certification.

The materials used in the construction of KLIA were stainless steel, concrete and granite – for the floors. Only in the holding area where passengers board their planes are carpeted.

One crucial component in any airport is the clarity of the Public Address (PA) system.

To reduce echo as a result of sound bouncing back from hard surfaces, the ceilings had to be perforated. By drilling holes in the ceiling, sound is absorbed and echo reduced, thus enhancing clarity of the announcements.

However, making holes on timber ceilings would cause these to break, so aluminum was used for this instead.

The integrated Total Airport Management System (TAMS) that broker's information from the various systems like passengers management, airspace management, passenger measurement, bay control among others was introduced in KLIA and was the only such system in the world at that time. Each system has its own protocol, but with TAMS, information on each of these can be accessed via computers.

It took about six months to transfer airport operations from Subang airport to KLIA. This operation to shift flight operations from Subang to KLIA overnight was dubbed: "Operation Readiness and Airport Transfer" which has since become a model for other planned airport relocations.

The main challenge for this project was time, and with efficient planning KLIA was transformed from a greenfield into a world class hub in six years.

The starting point was the Requirements Capture which had to be drawn up before the tender process commenced, from there the scope of work and concept was determined.

This was followed by detailed design of the airport, and a fast-track procurement strategy.

The master implementation programme coordinated jobs that could be done in parallel, and those which could be done in a series.

All other works had to be completed within the given time frame, while designs had to be perfected so that no changes would be required mid-way.

Three procurement strategies were implemented by the PWD. The first was the conventional strategy, followed by the 'design-and-build' and 'fast track' strategies.

Conventional procurement strategy required detailed design and tender. Payment was made progressively based on delivery of consultants appointed by PWD.

As for the design-and-build strategy, contractors took the lead in dealing with the consultants concerned. The Fast-track strategy was designed to coordinate parallel tasks.

PWD made sure that the interfacing was done as per requirements via a project management team. There were thousands of interfaces and there were often quarrels among the various parties so coordination and time management was crucial. However, despite the challenges KLIA was completed in six years.

One of the biggest challenges was managing people. This was done by putting in place procedures and systems that had to be adhered to, in addition to harmonising the various fields be it job management, supervision or contracts.

The team working on KLIA was a multinational team made up of British, Americans, Japanese, Koreans, Somalians and Russians. Although they came from diversified backgrounds we had one procedural system and everyone adhered to that. At peak construction period there were 25,000 workers.

The KLIA has 216 check-in counters and is designed to handle 100 million passengers per year

To ensure that jobs were completed in time, timelines were drawn up in the masterplan and if a job was not completed on time, surcharges were imposed because the delay of one element would have a snowball effect.

In terms of capacity and capability building, the PWD ensured that Malaysian contractors were selected to handle the more difficult sections of the airport. The idea was for these contractors to work together with international experts so that there could be knowledge transfer. About 80% of KLIA was constructed by local contractors.

The main regret that the PWD has today was that future plans for a low-cost carrier terminal was not included in KLIA's design.

This was mainly because at the time KLIA was designed and constructed; low-cost air travel was not a trend. However, because this was not captured in the design stages, KLIA 2 had to be built separately.

KLIA has won several awards since it was constructed and continues to do so in present times. These include the Skytrax and International Air Transport Association awards.

KLIA was thrice voted as the World's Best Airport (15-25 million passengers per annum) in the 2005 AETRA awards, 2006 ACI-ASQ awards and 2007 ACI-ASQ awards. In 2017, KLIA was named 'World's Best Airport for Immigration Services Award' at the 2017 Skytrax World Airports Awards in Amsterdam, Netherlands and was Platinum Winner for airports with 25 million passengers per anum and above category at Asia-Pacific Green Airports Recognition 2017 by Airports Council International ACI ■

The KLIA is capable of handling 120 aircraft movements at a time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Kuala Lumpur Sentral

Malaysia's largest Transit Oriented Development offers global connectivity and world class facilities

Kuala Lumpur Sentral (KL Sentral) is Malaysia's largest Transit Oriented Development (TOD) and has, over the years, established itself as 'central' to the Kuala Lumpur cityscape. Built on the back of the Malaysian Resources Corporation Berhad's (MRCB) vision for TODs, the overall development is equipped with international standard facilities and features prominent office towers, business suites, 5-star international hotels, luxury condominiums and a shopping mall. The Kuala Lumpur City Airport Terminal (KL-CAT) which is located within KL Sentral serves as an airport within the Kuala Lumpur City Centre and direct link to KLIA.

The realisation of MRCB's TOD vision has created a catalyst for the rejuvenation of the area and surrounding community. Coupled with its strategic location and global connectivity, KL Sentral has become a prime location for business, investments and living. Today, the development's Gross Development Value (GDV) stands at RM17 billion.

A snapshot of KL Sentral's history

In 1994, the Malaysian Government commissioned the nation's first TOD with the intention to transform Kuala Lumpur's old railway marshalling yard in Brickfields into an integrated development and a transit hub for the city.

Challenges in developing this TOD included working within the vicinity of a live railway system and high development costs that included site preparation, removal of underground obstacles, demolition of existing buildings and the irregular shape of land plots. As such, some of the important considerations for this project are as follows:

- The rapidly growing traffic congestion within urban areas;
- The growing desire for quality urban living;
- Creation of walkable cities and communities away from traffic;
- The expansion of the city's public transport system; and
- Implementation of Green Building requirements and reducing car park spaces within urban area.

The development of Stesen Sentral Kuala Lumpur commenced in 1997 and the RM1.1 billion world-class transit hub where seven rail networks eventually converged, is part of the KL Sentral blueprint, a masterplan that was designed and conceptualised by the same architect of the Kuala Lumpur International Airport (KLIA), the late Dr. Kisho Kurokawa.

Developed by the Kuala Lumpur Sentral Sdn Bhd, a consortium jointly led by MRCB, Stesen Sentral Kuala Lumpur now stands proud at the heart of the country's first TOD.

Based on a multilayer development concept with a deck built above the grounds of the KTM Intercity, ETS and Komuter railway tracks, there are five other lines that converge on/above/across this said deck at Stesen Sentral Kuala Lumpur namely the Light Rail Transit (LRT), the KLIA Express and KLIA Transit, KL Monorail and the Mass Rapid Transit (MRT).

KL Sentral is the largest transportation hub at the heart of the capital

Covered walkways and underpasses connects KL Sentral to nearby facilities to ensure a pleasant pedestrian experience

KL Sentral today

The project remains a significant milestone in MRCB's diverse portfolio and successful track record in project delivery, specifically in the areas of integrated urban centres, commercial and property development.

KL Sentral position as a TOD is complete with efficient bus and taxi services for the benefit of the general public and visitors to the City and functions as a connecting point for the local Rapid and intercity buses, taxis and buses to KLIA and KLIA2 as well as the KL Hop on and Hop Off tourist buses for the local Kuala Lumpur City Centre tours.

Various types of pedestrian bridges, covered walkways, covered underground walkways and underpasses were constructed to connect users to all buildings, hotels, a retail mall and commercial outlets, all within KL Sentral as to ensure pleasant and comfortable pedestrian walking experience around the development.

Building ahead

In addition to the integration of the transport systems at KL Sentral, MRCB has over the years incorporated Green building design and technology in all its TOD developments. In its Sustainability Statement, MRCB has committed to provide sustainable solutions that will help to minimise the environmental impact of its construction projects. Through continuous research of green building materials, technologies and delivery of quality standards, MRCB is on track in achieving its aim to develop sustainable buildings.

This commitment also involves the adoption of global benchmarks such as the Green Building standards such as the Leadership in Energy and Environmental Design (LEED) certification from the US Green Building Council, the Malaysian Green Building Index (GBI) certification and Singapore's Building and Construction Authority (BCA) Green Mark standards. To date, Stesen Sentral Kuala Lumpur, 1 Sentral, Platinum Sentral, Menara Shell have won several major awards including the FIABCI Prix D'Excellence Awards, The Edge Property Development Excellence Awards 2016 and the Property Insights Prestigious Developers Awards 2016.

At present, the notable buildings in KL Sentral are the Shell Tower, Ascott Sentral, Menara Allianz Sentral, Nu Tower 2, 1 Sentrum Tower, Q Sentral, 1 Sentral, Menara CIMB, Platinum Sentral, St. Regis Hotel, Hilton Kuala Lumpur, Le Meridien Kuala Lumpur, the Sentral Residences, Suasana Sentral, Suasana Loft and the Nu Sentral Mall.

KL Sentral facilitates more than 180,000 daily commuters

A vibrant, thriving and connected community

Today, KL Sentral facilitates more than 180,000 daily commuters, a number that continues to grow as the hub and its surrounding areas continue to benefit from the increased accessibility, visibility and higher real estate value. It is home to many multinational companies and local agencies like Facebook, Google, Shell, Cisco Systems, General Electric International, SBM Malaysia, the Regus Group, Seoul Commtech, the ICLIF Leadership & Governance Center, BP Asia, Axiata Group, PwC Malaysia and Government agencies like MIDA, Suruhanjaya Syarikat Malaysia (SSM), Land Public Transport Commission (SPAD) and the Performance Management and Delivery Unit (PEMANDU) and SME Corporation Malaysia (SME Corp).■

Kuala Lumpur Tower

The Kuala Lumpur Tower is a towering testament of architectural innovation, and represents the limitless possibilities ahead for Malaysia. It also showcases the Islamic heritage of the nation and upholds reverence for its natural surroundings in Bukit Nanas which is one of the last remaining pocket of rainforest in central Kuala Lumpur.

The statuesque Kuala Lumpur (KL) Tower represents one of the most ambitious projects ever undertaken in Malaysia. Though ultimately a state-of-the-art centre for telecommunications and broadcasting, the tower is also a model of innovation, converging elements of retail, leisure and entertainment.

Completed in May 1996, KL Tower also known as Menara KL, is today a major tourist attraction that draws local and foreign visitors, who ascend Bukit Nanas to take in the full glory of this 421m towering architectural wonder.

It is a highly-visible and prestigious landmark in the middle of the KL city's Golden Triangle. Since being launched on October 1, 1996, it has become a symbol of excellence marking the coming of age of a vibrant nation.

Also befitting the vision of a socially, economically and culturally vibrant nation, this tower is symbolic of Malaysia's technological prowess as well as her strong sense of cultural identity.

Menara KL combines elements of both modernity as well as tradition, striking a fine balance between both.

It stretches skywards towards a future of limitless possibilities, and is grounded in unshakeable foundation within Malaysia soil, rich in heritage and tradition.

When the Malaysian Government decided to build a telecommunications tower on Bukit Nanas to replace an existing steel tower, Telekom Malaysia (TM) was selected to be a party in that development as it was a major user of the tower.

It was also the national telecommunications company providing telecommunication facilities.

Through its subsidiary Menara Kuala Lumpur Sdn Bhd (MKLSB), TM was awarded the concession by the Malaysian Government to develop the tower under the concept of Build, Operate and Transfer (BOT).

At 421 m, the KL Tower stands among the tallest telecommunication towers in the world

The Petronas Twin Towers are visible from the KL Tower viewing deck

MKLSB was established in 1990, and awarded a 15-year concession commencing June 1994 to design, construct, finance, operate, manage and maintain the tower. It was to recoup its outlay from revenue earned after completion of the project.

At the end of the 15-year concession agreement, the tower would be transfer to the Government. The tower was the only and the main project for MKLSB which appointed a German company, Wayss & Freytag as the main contractor under the turnkey contract.

Wayss & Freytag was experienced in building towers, having successfully completed 30 such projects in Germany including the Frankfurt Tower.

The financing eventually came from a bridging loan facility of RM240 million provided by a consortium formed by Arab-Malaysian Merchant Bank with nine other financial institutions, including PNB.

Among the design considerations and requirements in place was that the tower should be built by people with technical knowledge and that the design is identified with Malaysia and its Muslim heritage, so that the tower exudes uniqueness and character.

The design process took three years to complete, and as the main contractor, Wayss & Freytag submitted its proposal on the design of the tower, specifying various engineering aspects, including the financial figures for each component.

MKLSB, for its part, was obliged to verify and approve all the design including the cost for the construction of the tower.

Air-conditioning was essential for the tower, both for proper functioning of telecommunications and broadcasting equipment in the tower head, and for the comfort of visitors during the day. The design thus included a high technology temperature control system.

The tower also incorporated a standby power system to ensure it could function in the event of a power failure.

MKLSB also went to great lengths to preserve the environment and greenery in the area.

Surrounding the tower is 9.37 hectares of the Bukit Nanas Forest Reserve, located in the heart of KL City Center. It is the oldest gazetted forest reserve in the country.

The natural surroundings of Bukit Nanas were monitored during construction of the tower, to ensure balance in development and environmental conservation. No less than half a million ringgit was spent to preserve a 110-year old Jelutong Tree (Dyera Costolata), where a retaining wall was constructed to protect the tree.

The design concept of the tower is based on traditional Islamic architecture. The lobby area at the entrance features dome shaped arches decorated with glass that illuminate like giants diamonds arranged in the form of Islamic architecture called the "Muqarnas".

This feature can also be seen in the lift lobby, soffit of the tower shaft and the whole of the tower head.

There were plans to include a glass lift for the tower shaft. However, due to budget constraints and space limitation, the idea was shelved.

The Tower as built with combination of concrete and steel.

Concrete was used for the tower base and shaft. This was to accommodate the varying diameter of the shaft. The slipform system was used, where the diameter of the tower shaft is reduced from 24.5m at ground level to 13.6m diameter at the height of 261.6m.

It remains constant thereafter, all the way up to the height of 317.16m.

The concrete structure has a complex geometry. The tower shaft for instance has decorative ribs, and its shape is not linear but parabolic to avoid the optical illusion of bulging.

The sliding formwork used to build the tower shaft had to be adjusted accordingly all the way to the top, first forming a large diameter base with a wall thickness of almost 1,500mm, and gradually reducing to a much smaller diameter, with a wall thickness of 600mm. This had to take into account features such as the ribs curvature of the concrete shaft.

The viewing deck of KL Tower offers spectacular view of the KL skyline

The fabrication and then the installation of the Muqarnas under the tower head was a challenge because of its location. The design of the tower head is complex, especially the glass façade. It required meticulous skill to make and install each panel of the steel frame, and integrate it with the glass to ensure a perfect fit.

Even the final paint palette for the tower shaft was unique. The architect specified a colour scheme that changed gradually from grey at the base to pink towards the tower head. This would be simple if it was a short wall, but painting on a shaft rising to a great height, with no platform to work on is quite a challenge.

During construction of the tower in 1990, there was very limited green building technology. However, MKLSB had customised the Building Control system dubbed as the Building Monitoring and Control System (BMCS) to control the main systems such as the Chiller/AHU system, pump system and lighting system. Other systems are also fully monitored.

The KL Tower was a unique project with a unique design, and because of this, every item on the tower was custom made. Nothing was off the shelf. The different diameter of the tower shaft, the complicated glass façade of the tower head, the curtain wall cleaning equipment, equipment cranes and the 86 meter tall antenna mass, all needed to be designed and fabricated for the tower.

Another challenge was the effect of temperature and climate on KL Tower, and how the shaft would bend away from the sun due to expansion on the side facing the heat.

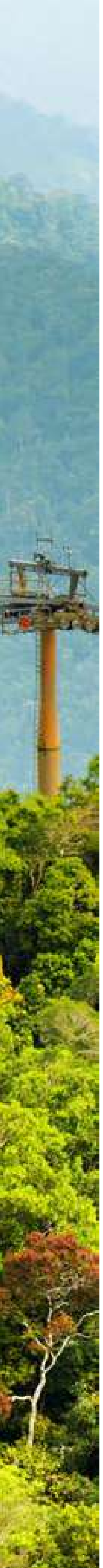
As the structure is very tall and slender, this effect caused numerous issues such as placement of the steel, the primary beam and the installation of the steel structure that connected the inner and outer reinforced concrete tower shaft together. To overcome these technical issues, work had to be carried out at night when heat was minimal. Most solutions in place to solve the issues and challenges faced during construction are in force even today.

The KL Tower was the only tower project in Malaysia during that period. Most of the technology used was considered new to the construction industry in Malaysia. However, as it is with other construction projects, project management skill was the most important criteria in ensuring the tower was completed within budget and schedule. Good coordination and planning between MKLSB, the architect, the management, and tight tracking and scrutiny of the main contractor's progress was the key factor for the project's success.

To ensure the project was delivered on time and within budget, the project was divided into three phases. Phase one involved the widening of Jalan Puncak, followed by phase two that focussed on the foundation and basement of the tower, and phase three which centered on the superstructure of the tower.

As main contractor of the project, Wayss & Freytag, which was responsible for design and construction of the tower, appointed a number of consultant to be part of the design consortium team for civil and structural (C&S), mechanical and electrical (M&E) and other systems at the tower. Wayss & Freytag also appointed and supervised works by local sub-contractors for installation and construction ■

Langkawi SkyCab and SkyBridge



Construction of the Langkawi SkyCab cable car is among the first in the country to prioritise environmental conservation and ensure minimal intrusion of the 550 million year-old Machinchang Range and steep mountain slopes on which it is located.

The Oriental Village at the base of Gunung Machinchang in Langkawi was completed in the year 2000. However the low visitor volume prompted then Prime Minister Tun Dr Mahathir to moot the building of a cable car system, to complement the attraction and help draw the visitors to the site.

As no private enterprise was willing to undertake the venture, Tun Mahathir who was also Langkawi Development Authority (LADA) co-chairman at that time, instructed the development authority to implement this project with funding from the Government.

LADA then appointed Angkasa Jurutera Perunding Sdn Bhd (AJP) as the lead consultant to design and supervise the construction of this cable car system.

AJP set up a full team comprising architects, planners, surveyors, environmentalists, geotechnical and geologists, civil , structural, electrical & mechanical engineers, forestry experts and economists to undertake the study and design.

The first task of the team was to set the alignment of the cable car.

The team of consultants were taken on an expedition hike up the hill where they studied ground conditions and recommended that detailed land survey, and soil investigations be conducted.

They also recommended suitable locations for cable car stations.

An aerial survey was also conducted on surrounding mountain landscape.

The final alignment was fixed after consultations between LADA, the consultants and suggestions from Tun Mahathir.

For LADA, the cable car project was seen as a saviour. It helped boost the number of visitor to the Oriental Village which did not have enough facilities and attractions to draw tourists. Known as the Langkawi SkyCab, it has become an important attraction and an added tourism product for Langkawi.

In terms of design, the most important consideration for this project was public safety and preservation of the natural mountaintop environment. The project site is on what is recorded as the oldest part of South East Asia and the first to emerge from the ancient sea and estuary.

There was to be minimum disturbance and intrusion of ground on the steep slopes, and minimum clearing of vegetation. Buildings for this cable car system were therefore built on stilts and the design required very minimum ground clearing.

Being a pioneering project in an environmentally sensitive location of geological importance, all design decisions had to constantly take into consideration sustainable architecture, landscape conservation and environmental impact of the design.

The design process and on site studies took more than six months. AJP was appointed in April 2000, the designs completed in November 2000, and tenders called in December 2000.

Tun Dr Mahathir, LADA's General Manager Tan Sri Abdul Halil and technical engineer, were constantly briefed and consulted both on the studies that were carried out, the alignment, building concepts and equipment selection.

Materials selected had to be durable, long lasting and able to withstand the tough mountainous environment.

LADA felt that it was important to incorporate green building design and technology in this project, because this was a pioneer project at a time when the green movement was at its infancy.

The development authority also wanted to showcase this project as one of the early environmentally friendly projects in Malaysia. Membrane roofing, open concepts and natural ventilation features were implemented toward this.

Lack of accessibility to the site, especially for heavy construction machinery and equipment were among the major challenges faced.

To overcome this workers had to walk up the mountain, where temporary camps were built for them. Helicopter, winches, temporary working cable and simple hoists were used to handle heavy equipment and materials.

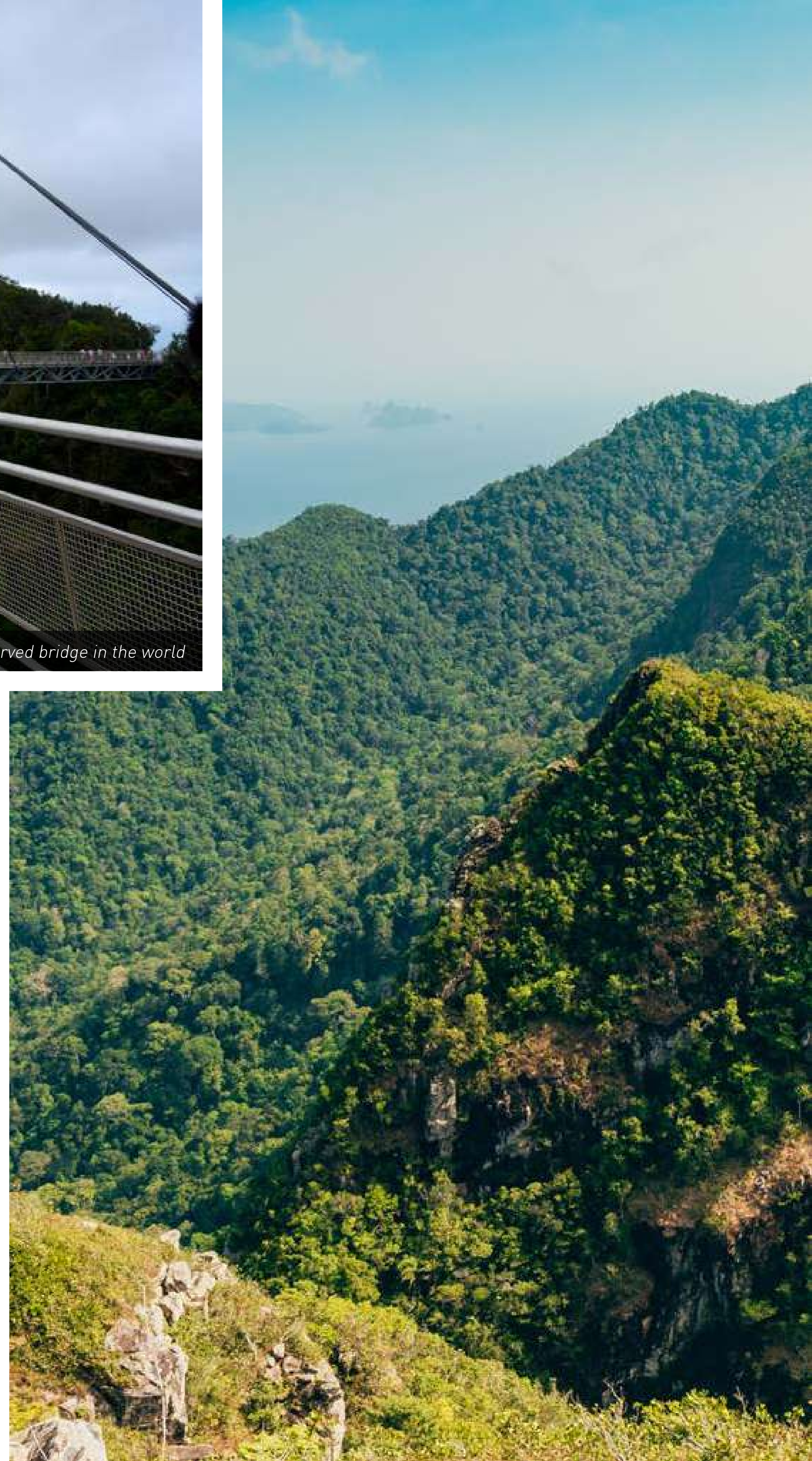
The Langkawi Cable Car was the second cable car project in Malaysia at that time, the first being the cable car system in Genting Highland.

The Genting Highland cable car system was however built on easily accessible ground, whereas the Langkawi Car was to be built on steep mountains without road access. The 2.2km SkyCab ride from the Base to the Top Station takes about 20 minutes. A short walk up the stairs from the Top Station at an elevation of 708m above sea level will take visitors to two viewing platforms atop Gunung Machincang, with panoramic views of Langkawi Islands and Southern Thailand on clear days.

The Langkawi SkyCab project team only had previous experience of building in thick jungle without vehicular access. Together with engineers and Austria based equipment supplier Doppelmayr, they drew up a detailed construction program to build the cable car installation using a combination of helicopters, winches, a working cable and simple hoists.

No heavy machinery was used in the construction of the Middle and Top station buildings. Key lessons from building in sensitive environments and a detailed environment management plan helped the team ensure success.

Langkawi Skybridge boasts the longest free span and curved bridge in the world



The Langkawi Sky Bridge is a 125-metre and 1.8-metre wide curved pedestrian cable-stayed bridge in Malaysia, which was completed in 2004. The bridge deck is located 660 metres above sea level at the peak of Gunung Mat Chinchang. The Skybridge can be reached by taking the Langkawi SkyCab to the top station, where an inclined lift called SkyGlide takes visitors from the top station to the bridge.

The bridge is suspended from a 82m high single pylon which hangs at about 100m above ground and it can accommodate up to 250 people at a time. The pylon is anchored onto a concreted pad set at an elevation of 604.5m, and its tip reached 686m above sea level. It is inclined at angles of 78° and 2° in two directions, and supported by two cables. It swings out over the landscape to give visitors a unique spatial experience, and to bring them into otherwise unattainable locations, above virgin jungle with spectacular views.

Measuring 125m in length, the structure ranks among the world's longest curve suspension bridge and constructing it was definitely not an easy feat. The team responsible to construct it has to consider the following critical elements; structural balancing from a single point (top of the pylon), optimal weight management and load distribution, pre-fabrication of bridge and onsite installation. Even more daunting, the entire bridge, in all its elements, had to be lifted to the top of the mountain by helicopter and then assembled to its position. Helicopters were also used in the erection of the pylons and the main section of the deck. The deck sections which were built later however, were assembled using more conventional were working cable and winch system. The bridge roughly costed $1.2 million dollars to construct within 12 months from August 2003 and August 2004. It was opened to the public on February 2005 ■

The Skycab and Skybridge projects were constructed with minimum environmental impact

Light Rapid Transit (LRT) Line Extension Project (LEP)

Prasarana Malaysia Berhad's (Prasarana) experience in rail projects was an advantage in dealing with the myriad of challenges that came with the Light Rapid Transit (LRT) Line Extension Project (LEP).

One of the main challenges faced by the Light Rapid Transit (LRT) Line Extension Project (LEP), which extends the Kelana Jaya and Ampang LRT lines, was the efficient and effective mobilisation of resources to support this project which involved numerous parties.

The project involved the laborious task of planning route alignments, land acquisition, public engagements, logistic coordination, manpower coordination, safety management, in addition to the design and construction of lines and stations among others.

A clear line of communication and project structures were necessary to establish and ensure smooth coordination and implementation of works. All parties needed to be clear of their roles and limit of authority, thus, a reporting structure was established to ensure that progress of the project was monitored systematically, and that all issues were discussed and resolved by the relevant parties.

On the technical front, plans had to take into account the standards and specification of existing lines. Also taken into consideration were required upgrades to replace obsolete features of the previous Ampang and Kelana Jaya lines which were more than two decades old.

Construction and design of the extended line also prioritised improvements to existing facilities, including areas such as passenger mobility, universal access, and facilities. Integration with the existing public transportation systems was also one of the main aims of this project.

Subsidiaries of Prasarana, Prasarana Rail and Infrastructure Projects Sdn Bhd (PRAISE), and Rapid Rail Sdn Bhd (the operator and internal client) participated actively in the design process. Regular meetings were held to review design concepts and submissions.

Smooth integration with existing public transportation systems is the main priority of the LEP

Among some of the important considerations taken in terms of the design and construction were standardisation of station designs, fulfilment and incorporation of requirements stipulated by local authorities (as the project traverses through heavily populated and built up areas) and working hours that do not disrupt the public and traffic conditions.

The design process took almost two years (March 2009 and Jan 2011). The process included the finalization of the railway scheme.

To minimise negative impact on the environment, the stations have been designed with landscaped areas, wherever possible. Natural lighting and ventilation keeps the concourse areas of the station and platforms bright and cool, while rain water harvesting technology collects rainwater for watering landscaped areas and for toilet flushing.

Materials used for construction in this project were durable, sourced locally and easy to maintain.

These include reinforced concrete for station frame structures, steel structure for roof truss and metal sheets as cover/cladding.

Composite panels were used for the building finishes/cladding, and aluminium for the louvers and glass for railings.

The project also incorporated new technologies such as Ethylene Tetrafluoroethylene (ETFE) for the guideway envelope of the LRT Kelana Jaya line to minimise visual impact to nearby residential buildings.

ETFE is considered choice material for skylight applications to long span structure of building facades. It also has high corrosion resistance to wide temperature and weather conditions.

Another challenges faced by this project were public feedback to the proposed alignment, the long and tedious land acquisition process, utility relocations, integration with the Keretapi Tanah Melayu Berhad (KTMB) Subang Jaya Komuter station, changes to designs due to construction methodology constraints - such as that to Station 3 of the Kelana Jaya line where reinforced concrete slabs had to be replaced with steel/permanent slab support designed to avoid interruption of traffic flow along Jalan Lapangan Terbang Subang, the interface management between facility works and systems work packages, and traffic management during construction along busy roads and highways, in addition to safety management.

The LEP extends the connectivity of the LRT network to 15 new stations including the Putra Heights interchange

To overcome these challenges, roadshows were held to meet the public, while regularly following up on land acquisitions with the land office.

Trenching and piloting of existing utilities were carried out concurrently, and new plans or designs implemented to relocate, avoid or protect utility lines.

Design changes were made where necessary, like the hand dug caisson in lieu of bored pile at the Subang depot site. Strict review was conducted on contractor's traffic management plans and its execution on site.

A safety patrol unit was introduced to address safety management. Improvements made to safety measures included the 6-meter high free-standing casing for bore piling work, third party inspections on cranes and lifting equipment, ensuring all cranes and machinery are less than 15-years old, while operators of these machinery are required to have at least five years of experience in the field.

Permits To Work (PTW) have to be obtained before commencing work, and high level safety meetings are held regularly, in addition to periodic and ad-hoc site audits.

Key lessons learnt from this project included the fact that utility relocations should be carried out by the main work package contractors in order to minimise interfacing risk and delay.

It was also ascertained that piling works should start at multi fronts wherever possible not only to expedite construction progress but also to help in identifying early when there is lack of accurate as-built information.

Early approval of the final railway scheme is critical in ensuring that the alignment is fixed, station layouts firmed up and that detailed designs can proceed with certainty.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Finalisation of the project procurement and contract strategy is critical to ensure preparation of tender documents and drawings can proceed so that the scope of work, including delineation and demarcation can be finalised on time. To do this, the role of local authorities and councillors are important in engaging the public.

Prasarana's previous experience with rail projects were an asset in handling the major challenge of land acquisition for the project. Based on its experience, the utilisation of a time chain diagram to complement the Primavera Bar Chart programme was an excellent project management tool for project management and planning purposes.

Similarly, the "Access Conditions" methodology for interface milestone dates between various contract packages that the company used for the PUTRA LRT project in 1996 was also applied to this project.

Prasarana attributes a strong management team with adequate number of personnel with the relevant railway project experience for its success.

Teamwork between project management staff, competent contractors with adequate resources and cash flow, and competent design consultants were critical in ensuring that all components of the project fell in place.

In addition to this, punctual progressive payments from clients to contractors, and frequent monitoring of contractors was important to ensure the project was delivered on time and within budget.

This project represented a major milestone for the LEP, as it was the first of many more rail projects to be rolled out in the Klang Valley after 15 years of inactivity. LEP's strength was its economic efficiency of the investment through maximum utilisation of existing resources and assets to widen and increase the rail network ■

Menara Kerja Raya

Jewel in the Crown

The Menara Kerja Raya Tower dazzles the city skyline with its unique 'Jewellery Cut' design that reflects the role of the Works Ministry as 'The Diamond in The Crown of the Local Construction Industry'.

The Menara Kerja Raya (MKR) tower on Jalan Sultan Salahuddin in Kuala Lumpur stands out in the city skyline with it glitzy 'diamond' façade designed to reflect the role of the ministry as 'a diamond in the crown of the Malaysian construction industry'.

At approximately 175 meters tall, this tower accommodates 1,600 staff from the Ministry of Works as well as Public Works Department (Jabatan Kerja Raya) Malaysia in 51,516 square meters of floor area. Presenting itself as a "Diamond in the sky" the MKR tower comprises of 37 unique floors and a 7-storey elevated car park podium. The tower is a part of the MKR complex which is located on one million square feet of prime land in the city.

Ahmad Zaki Sdn Bhd secured the contract to build this tower worth RM309.4mil from the Public Works Department in late 2009, while GDP Architect Sdn Bhd was appointed as consultant architect.

The fluid MKR tower required both exceptional construction and design methods to execute its complex geometry. Its design included a triangular footprint that tapered upward into a leaf-shaped roof at the top.

The verticality of the tower is enhanced by external fins to the building's envelope, while alternate glazing modules offset in and out of the facade, not only acts as a natural sun-shading device but also accentuates the building's curvature, expressing a jewel cut effect.

Structurally, the tower sits on a bored pile and caisson foundation with 20 slanting columns per floor slab. Each individual concrete column is unique in size and shape. This building has a rigid frame system that achieves lateral stability in areas where there is low seismic activity.

The challenge in terms of this rigid frame structure was the varying beams and columns sizes required to be fabricated. These were combined with the core structure to increase lateral resistance – especially for a building as tall as the MKR tower.

The diamond-shaped façade signifies the important role of the Ministry of Works in the development of the country

The external fins surrounding the building act as natural sun shade

The MKR building uses a skeleton frame that is suitable for tall structures and commonly used in Malaysia. Even this was a challenge due to the varying structure members. However, to speed up the process the project adapted the formwork system which is easily dismantled for reuse.

Two static tower cranes were used to lift materials at the site, while concrete pumps were utilised to pump concrete to the higher levels of the structure.

MKR received the Green Building Index (GBI) Platinum final certification which affirms its effort to include energy saving and sustainability features in its structure.

The building incorporates many features to reduce energy consumption, improve occupant comfort, reduce the impact of material usage as well as make use of less treated potable water.

The tower design incorporates floor to ceiling glazed facades which are exposed to the east and west orientations, but despite this it manages to reduce solar heat gain by employing triple pane insulated low-E glazing.

This is coupled with efficient lighting design with a low 8W/m2 lighting power density and automated control which effectively turns off 40% of the office lights during daytime. In addition the design features an air conditioning system that is able to reduce fan power down by more than 50% on reduced load days.

This building achieves a very respectable Building Energy Intensity (BEI) of about 90kWH/m2year, which is about 60% lower than buildings that are designed to merely meet MS 1525 guidelines. This saves the Government approximately RM2.5mil per year in electricity charges at the current energy rates.

An overall daylighting strategy played a huge role in creating a unique and much comfortable indoor environment in this building. Custom perforated venetian blinds, low height workstation and glass partitions for private offices and discussion rooms synergise to create an open well-lit office space that is conducive for occupants.

The design allows usable daylight levels of up to 6 meters from the façade, which allows automatic shut off of lights over these areas.

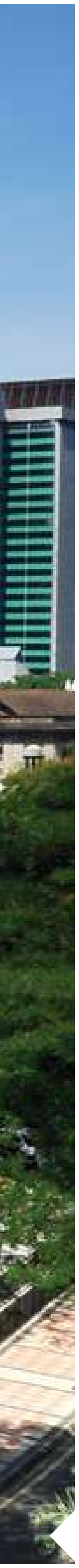
The MKR tower is also one of the first buildings to incorporate a waste water treatment system that treats greywater from wash basins, floor traps and ablution to be reused within the building for toilet flushing and landscape irrigation.

A 400 cubic meter underground rainwater harvesting tank captures plenty of rainwater to be used for similar purposes in the building when there is rainfall.

These strategies and the use of low flow fixtures in toilets and for ablution, as well as significantly lower cooling load resulting in lower cooling tower water usage and has resulted in reduced water consumption per square meter floor area by at least 70% when compared to other similar buildings.

In 2017, the MKR tower won two Malaysian Construction Industry Excellence Awards (MCIEA); the Best Major Project Award for building construction and the Green Construction Award ■

National Mosque of Malaysia



The main roof resembles an open umbrella and the minaret's cap resembles a folded parasol

A Beacon of Freedom,Unity and Peace

The National Mosque of Malaysia was built to commemorate the independence of Malaysia from colonial forces without violence and bloodshed, despite its complex multicultural society which was a rarity in that era.

The National Mosque of Malaysia is one of the iconic buildings that is synonymous with the Kuala Lumpur city's skyline.

Completed in 1965, this mosque was a symbol of freedom and unity for the people of Malaysia – then a newly independent country.

The idea was conceived by the Federal Executive Council on July 30, 1957 – a month before the declaration of independence on Aug 31, 1957.

This mosque, built on a 13-acre site surrounded by greenery, reflecting pools and fountains, was initially to be named Masjid Tunku Abdul Rahman Putra Al-Haj; in recognition of the first Prime Minister's role in obtaining independence for the country.

However, Tunku refused this honour and chose to name it Masjid Negara in thanksgiving for the country obtaining independence peacefully, without any bloodshed.

United Kingdom architect Howard Ashley, and Malaysians Hisham Albakri and Baharuddin Kassim from the Public Works Department (PWD) designed the mosque that was built on land which had (since 1922) housed a church – the Venning Road Brethren Gospel.

This site was acquired by the government to build the National Mosque which was completed and declared open by the third Yang di-Pertuan Agong, the late Tuanku Syed Putra of Perlis.

The bold and modern design of the mosque was inspired by the modern architectural style at that time, known as the international style, and fashioned to reflect the aspirations of a then newly independent Malaysia.

It, however,, departs from the traditional domed mosque designs and incorporates local design features.

The National Mosque that has a capacity for 15,000 faithful has several unique features such as the 74.7-metre-high minaret and a 16-pointed star concrete main roof.

The main roof resembles an open umbrella that is synonymous with Malaysia's tropical climate, while the minaret's pinnacle resembles a folded parasol that symbolises the strength and unity of the people of the newly independent Malaysia.

This is especially significant when one takes into account the fact that RM3 million in donations from Malaysians of various creed and religions covered part of the RM10million construction cost of the National Mosque.

This main 'umbrella' or roof has a diameter of 200feet (60.9 metres) and is supported by 16 reinforced concrete pillars, while the 245-feet-high (74.7m) minaret is equipped with an elevator that can transport passengers to 140 feet (42.7m), where a cantilevered platform was incorporated for the call to prayer by the muezzin could be performed here five times a day.

Though the RM10 million construction cost for the mosque was considered as a considerable amount in those days, it was still a challenge to construct a monument of such stature.

Several modifications had to be made to reduce costs like using terrazzo for flooring instead of marble.

There were limited choices of construction materials back then. Basically, contractors only had concrete to work with as this was in the days before the introduction of steel and aluminium framework.

Thus, the basic structure of the mosque and even the roof were made of concrete.

The original design of the mosque had pink tiles decorating the roof and walls of the structure, but following major renovations in 1987, these were replaced with green and blue-hued glass tiles.

The building consists of a prayer hall, multipurpose hall, the warrior mausoleum, a library, offices, open courtyard and the minaret.

The main prayer hall and a reflecting pool occupy the upper deck, while deep verandas screened off by grilles in traditional Islamic design surround the grand hall that can easily accommodate over 8,000 devotees.

A multipurpose hall located on the south side of the mosque serves as an all-purpose hall with a seating capacity of 500pax.

The National Mosque also houses a mausoleum comprising seven tombs known as the Makam Pahlawan (Heroes' Mausoleum) and is connected to the main building by a covered foot-bridge.

This circular mausoleum, at the rear of the mosque, stands in a circular reflecting pool and is covered by a seven-fold pleated shell concrete dome.

The mosque courtyard is partly covered by 48 independent concrete parasols.

These provide shade from the sun and shelter from heavy tropical rains. On the floor below is a fountain built for an ablution area.

The National Mosque of Malaysia which celebrated its Golden Jubilee on August 27, 2015, remains as one that embodies a unique and modern design with a contemporary expression of traditional Islamic architecture, art, calligraphy and ornamentation ■


North–South Expressway (Malaysia)

Completed in 1994, the highway brought economic benefits to cities and towns it connects

The North-South Expressway project was a herculean and financially challenging project for the government of Malaysia. The idea was mooted in 1977 by then Deputy Prime Minister Dr Mahathir Mohamad (now Tun).

In the mid-1970s there were indications that the Malaysian economy was reaching a crucial stage of development and evolution. One indicator was the dramatic increase of traffic volume on Peninsular Malaysia roads. The increase of lorries was significant enough to suggest a growing volume of freight transported by road.

The standard of living was clearly rising, and it was at that time that Mahathir remarked about the development of a highway from the northern border with Thailand to Johor Bharu in the south.

In the 1980's policymakers acknowledged that roads and infrastructure would play a crucial role in moving the country forward as industrialisation overtook tin mining and rubber cultivation as mainstays of the Malaysian economy.

It was decided that four main areas should be refined in the path towards becoming a developed nation: infrastructure, agriculture, industrial and social services.

On April 24, 1981, Dr Mahathir who was by then Prime Minister officiated the ground breaking ceremony for the expressway at Bukit Kayu Hitam near the Kedah-Thailand border.

By a special enactment of Parliament, the Malaysian Highway Authority (MHA) was formed in 1980 to supervise and execute designs, to collect tolls and dues from users, to carry out research towards efficient utilisation and carry out improvements.

Although construction was to be carried out by private enterprises, ownership and control remained in the hands of the government.

For road users and local businesses, the PLUS Expressway meant a safer and quicker passage to their destinations compared to trunk roads.

The mammoth task involved the preparation stage where papers had to be presented, feasibility studies carried out, detailed engineering surveys made, designs prepared, land acquired, alignments determined and the cooperation of state governments obtained.

Decisions had to be made on whether construction was to be elevated, at grade, underground or over water.

Running through the varied landscape of Peninsular Malaysia meant encountering a varied set of challenges along the over 800 kilometre stretch.

These included rivers, soft soils, peat bogs and hills of granite.

PLUS's project management company Pengurusan Lebuhraya Bhd managed to resolve these with significant reductions from the original cost estimates, including a long stretch of soft marine clay between Juru in Seberang Prai and Changkat Jering near Taiping, Perak, and another between Ipoh and Bidor, Perak.

Embankments had to be constructed to carry the highway over soft soils.

However, the conventional method of building embankments on piles of the requisite length driven into the soil to its bed resulted in a "mushroom effect" as different parts of the embankment settled at different rates, resulting in depressions on the road surface.

The mushroom effect was visible in parts of the protruding embankment where pilecaps settled less than the surrounding embankment.

Usually concrete slabs will be placed on the piles, and the heavy earth embankment on the slabs, to prevent the embankment from subsiding.

This method though effective, is time consuming and expensive, so PLUS did away with it and came up with a cheaper and quicker solution.

Along stretches where the embankments were not too high, unnecessary piles and slabs were removed and the earth embankment placed directly on the soft clay.

The embankments were preloaded during construction to induce settlement that would ultimately occur over time.

In Johor, the peat bogs between Ayer Hitam and Sedenak were resolved.

Credit is due to the labourers who came up with a solution to traverse a 17 kilometre stretch of peat bog in Johor.

Initially the preferred plan was to construct a series of viaducts across the whole stretch – a difficult and expensive option.

The workers offered a solution they themselves have been using to build their homes.

The NSE is the longest expressway in Malaysia with the total length of 772 km

They suggested draining the land, excavating the peat and replacing it with ordinary soil.

Though PLUS was initially reluctant due to the large scale of the expressway project, a trial conducted at an area in Machap, Johor found that it was workable.

The peat which was between 5 to 10 metres deep were drained and filled with compacted soil.

The method was applied to half of the total section affected, thus reducing the cost.

Solutions applied have to be in accordance with standards set by the Malaysian Highway Authority (MHA), and specifications agreed to in the concession agreement.

The PLUS Expressway exceeds some of these specifications and standards.

For instance, almost 143 kilometers or 2.63 million square meters is constructed with continually reinforced concrete pavements (CRCP).

It was stipulated in the concession agreement that a minimum of 30% of the Expressway built by PLUS use concrete pavement.

CRCP has a design life of 40 years and is one of the most expensive and durable road surfaces.

The concrete slabs are 26 centimetres deep on heavily trafficked sections and 23 centimetres on other parts of the expressway.

Construction for this section of the expressway required 850,000 tons of stone products, 650,000 tons of concrete, 350,000 tons of sand, 250,000 tons of cement and 45,000 tons of high tensile steel reinforcements.

The raw materials for this were sourced within Malaysia.

In the early plans, over 300 bridges had to be built, and over 70 interchanges, 40 lay-bys and 18 rest and service areas constructed.

Today there are 81 interchanges, 22 rest and service areas and 48 lay-bys.

The initial estimated cost of construction was RM2.65 billion and estimated time of completion was six years. However, owing to the economic slowdown and recession in the 1980's the cost was stretched to RM4 billion.

The expressway was completed in 1997, and today about 1.5 million vehicles ply PLUS operated highways every day.

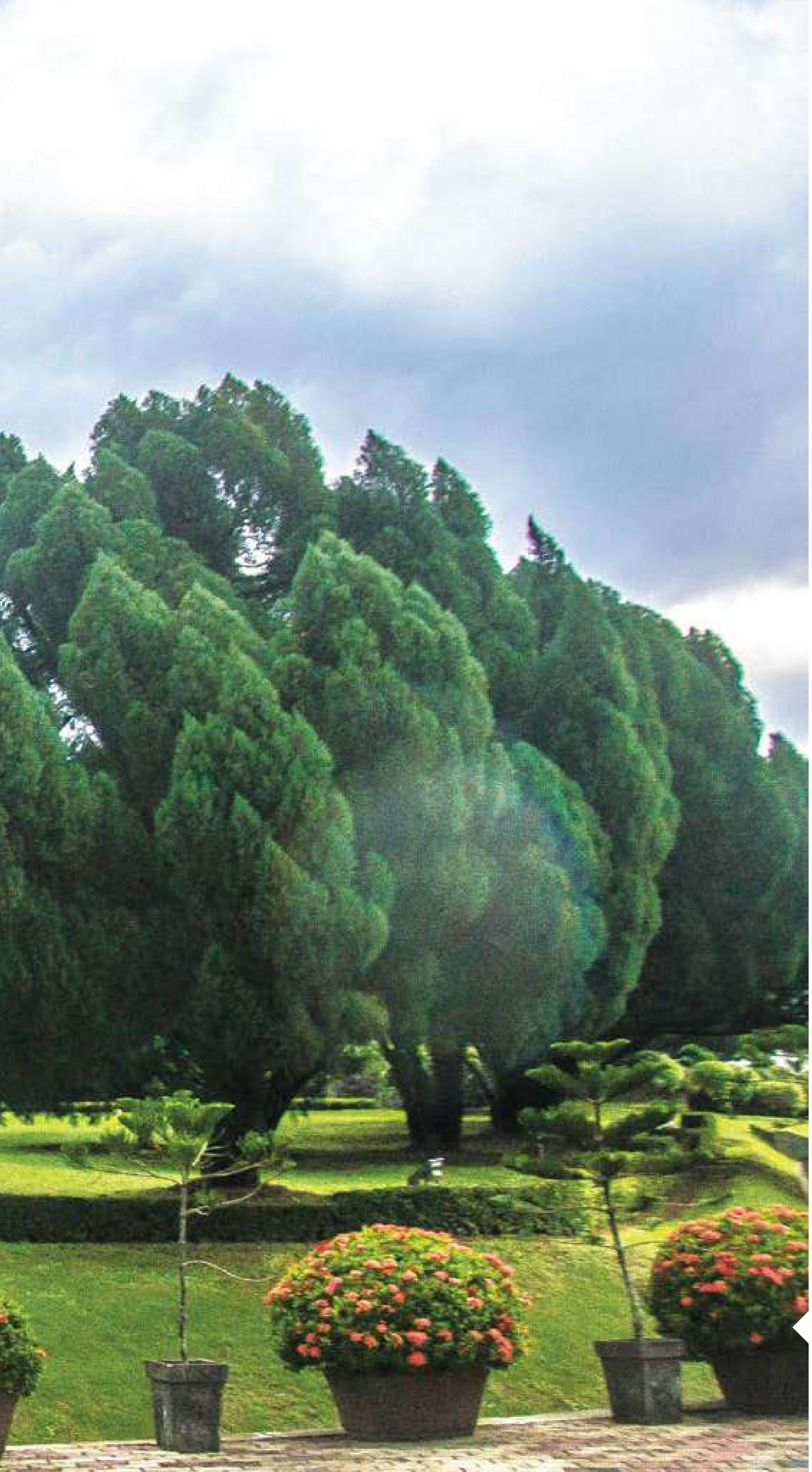
Upgrading works are done from time to time to keep up with current demands and improve safety aspects of the highway.

In 2012, PLUS embarked on the fourth lane widening project along stretches with high traffic volume along the North-South Expressway.

This project involves 63.3 kilometres and will include expansion along the Shah Alam to Sungai Buloh, Bukit Lanjan to Jalan Duta, Sungai Buloh to Rawang, Nilai Utara to Nilai, and Nilai to Seremban/Port Dickson stretches ■

About 1.5 million vehicles ply the PLUS highway everyday


PARLIMEN
MALAYSIA



Parliament of Malaysia

The Malaysian Parliament building is an iconic structure that represents the sovereignty and the democratic system of the country. It is a building that Malaysians and most foreigners will be familiar with being etched on our coins, banknotes, stamps, tourist brochures and books on Malaysia. The grey and white structure on what used to be known as West Folly hill in Kuala Lumpur stands out amongst the lush greenery of the Kuala Lumpur Lake Gardens that surrounds it.

The idea for the construction of Malaysia's very own Parliament House came from Malaysia's first Prime Minister Tunku Abdul Rahman in 1959, two years after independence from the British.

A statue of Tunku (who is also known as the 'Father of Independence' and 'Father of Malaysia') at Parliament square, was designed by Austrian born American sculptor Felix de Weldon who also designed the national monument Tugu Negara.

Built at a cost of RM18 million, the Parliament House replaced the first meeting halls for the Dewan Rakyat and Dewan Negara which were located at what is today known as the Malaysian Tourism and Information Centre (MATIC) on Jalan Ampang.

The Malaysian Parliament complex comprises of a 3-storey main building that houses the Dewan Rakyat (House of Representatives) and Dewan Negara (Senate), and a 17-storey tower where administration offices, and the offices of the Prime Minister, Deputy Prime Minister, Minister in the Prime Minister's Department and opposition leader are located.

Members of Parliament (MPs) who initially occupied offices in the tower block were relocated to a new building when Parliament was refurbished between 2013 and 2018.

Construction of the Parliament Building commenced in September 1962. It was completed and officiated more than a year later by third Yang di-Pertuan Agong Tuanku Syed Putra ibni Almarhum Syed Hassan Jamalullail on November 2, 1963.

The building designed by British architect Ivor Shipley who was at that time attached to the Public Works Department (PWD), is located on a 16.2ha site on what was known as West Folly Hill in the capital city. This hill was levelled during construction.

The parliament building is one of the earliest iconic structures ever to be built in the city

The foyer of the newly renovated building is decorated with beautiful and intricate designs

More than a million bricks, 2,200 tonnes of steel, 54,000 tonnes of concrete, 200,000 bags of cement and 300 tonnes of glass were used to construct this building which unique architecture was further enhanced by the beautiful landscape around it which included a pool and fountain situated between the Main Block and Tower Block.

The Main Block which hosts the House of Representatives has three storeys 380 X 290 feet in size, with a unique roof-top design of 11 triangle shaped pinnacles. This block features a pineapple-skin like facade made of terrazzo (11 feet in height and 40 inches in width), which doubles up as a sunscreen for the building. Within the facade are glass panel walls.

The 76.2m high, 17-storey Tower Block is connected to the Main Block by two 50-metre bridges. Originally, the Tower Block housed the offices of ministers and Members of Parliament (MPs).

However, with the increasing number of staff, the Tower Block was converted into administrative offices.

The building has a separate walkway for His Majesty the King (left) and for general building occupants (above)

Only the Prime Minister's Office at level 2, Deputy Prime Minister's Office at level 3, Minister in the Prime Minister's Department (Parliamentary Affairs) Office at level 15, and Opposition Leader's Office at level 14 remain.

Anjung Parliament, an open space on Level 17, which is the highest level with breathtaking views of Kuala Lumpur city's skyline, is frequently used for functions.

The parliament hall is equipped with various other facilities and amenities like a canteen, carpark, media centre, clinic, MPs lounge and even a multipurpose hall equipped with recreational facilities such as tennis, badminton, futsal and volleyball courts, gymnasium, and sauna room to be used by Members of Parliament and staff.

The Parliament Building also houses a banquet hall that can accommodate 500 guests at any one time.

The surroundings of Parliament are beautifully landscaped with various types of plants including the rare Banyan Tree (Ficus Benjamina) and Rain Tree (Samanea Saman).

A Deer Park between Parliament and the Kuala Lumpur Lake Gardens is a playground for dozens of Axis deers that are descendents of the first pair gifted by President Suharto to the Malaysian Parliament in the 1980s.

In 2007, the Parliament Building was gazetted as a National Heritage Building under the National Heritage Act 2005.

As this iconic building approached its 50th year of operation, the weather beaten exterior and worn interior required repair and maintenance, while the building itself needed expansion and renovation to ensure that it could serve its purpose for decades to come.

The walkway to the Prime Minister's office has a modern and clean design

This refurbishment project was carried out in phases by the PWD between 2013 and 2018. It was a significant project for the PWD as it was an iconic and historic building that houses one of the most important establishments of the country.

Phase 1A of the refurbishment involved the construction of temporary facilities for the Dewan Rakyat and Dewan Negara prior to major renovation works. This was followed by rectification works on the Pinnacle of the existing Dewan Rakyat in phase 2A.

Phase 2B involved renovation and conservation works to the old main block, while phase 3A was focused on M&E works.

Phase 3B to construct a brand new MPs block and other support facilities is underway and due for completion in 2018.

Phase 2B of the Parliament refurbishment project encompassed conservation works on this iconic building and had influenced the design of spaces, and the selection of materials.

This phase also required careful planning as it was bound /gazetted under the National Heritage Act 2005 - National Heritage Category. Other phases were not so stringent and were approached in a more progressive manner.

Materials used were mostly traditional in nature. However, new lightweight block technology and concrete infill panels were also used to ensure building materials were light, as the superstructure of the building was already 54-years old and was not really designed to accommodate current building standards. Carbon Fibre Reinforced Panels (CFRP) were used in this phase to structurally strengthen the old floor slabs and columns.

In Phase 3B, designers are incorporating modern and dynamic designs that take into account green building, and sustainable designs and features. These include features that minimise heat penetration like sunlight filtering facades and e-glass. External aluminum panels for the facade were specified to ensure sustainability and also as an option for recycling in the future.

Rainwater harvesting and solar panel technologies are also included in the design. Steel was selected for the main superstructure systems in Phase 3B, with hollow core slab flooring. This was in the interest of construction speed and weight reduction.

Designers were pushing for a more dynamic facade to propel the image of a parliament that was ready for the next millennia; however, due to cost and primarily conservation requirements, the facade was kept at a more traditional tone ■

Penang Bridge

This towering, beautifully designed iconic structure is synonymous with Penang Island. It is also recognised and appreciated for the social and economic boost it has given to the island by linking it to mainland Peninsular Malaysia.

If Penang was to achieve the growth rate warranted by its potential, a physical link between the island and Seberang Prai (Province Wellesley) on mainland Peninsular Malaysia was necessary.

It was with this in mind that the government appointed a firm of consultants, Christiani Nielsen A/S of Copenhagen, Denmark in November 1971 to conduct a feasibility study on this idea, followed by preliminary design submissions, detailed design and tendering, and finally construction and supervision.

The initial design for a low level bridge was however reviewed by the government in September 1975, in favour of a high level one with vertical clearance at the South Channel to allow ships with masts of up to 30m and a minimum navigational opening of 150m in width.

Among matters taken into account when deciding on the alignment of the bridge were the Penang Port Commission's Proposed Bulk Cargo Terminal, the Electricity Board Prohibited Anchorage Area, and the location and direction of the South Channel and the Western Channel.

Despite the magnitude and complexity of the Penang Bridge Project, it was completed on schedule, thanks to good and efficient project management which resulted in considerable savings.

The savings made it financially possible to take advantage of the favourable contract rates to increase the width of the bridge from four to six lanes before completion, and include the construction of the Udini Link.

The 13.5 km bridge is among the longest in Southeast Asia

The Penang Bridge project was a testament to what can be achieved when there is good cooperation and team effort between contractors, consultants, and government departments and agencies involved in the project.

The 13.5 km bridge which was opened to traffic on Sept 14, 1985 was bestowed the Grand Award by the Council of Consulting Engineers, Washington the following year.

In 1993, it won the FIABCI Special Award (Development and Construction Phase Category) from the International Real Estate Federation of Malaysia.

The Government spent a total RM800 million to build the bridge.

The bridge took about three and a half years years to complete and was officially opened to traffic on Sept 14, 1985 by Deputy Prime Minister, Y.A.B. Datuk Musa Hitam.

This Bridge is the first physical link between Peninsular Malaysia mainland and Penang Island which was at one time only connected by ferry services.

The channel crossing consists of elevated bridge structures known as "Cable Stayed Concrete Girders".

After considering a few designs, the government decided to go with this bridge type, which had a main span of 225m.

The advantage of this design was that it could be widened in the future, in addition to being the most economical type for the initial construction.

The unique design of this bridge has made it a landmark both in Penang and in Malaysia, and has significantly contributed to the development of the island both as a tourist hub and industrial centre.

The unique design of the bridge has made it a national landmark

At the peak of construction about two thousand Malaysians and one thousand Koreans were engaged in jobs, and on the job experience was provided to many engineering undergraduates and graduates.

The South Koreans were mainly employees of Hyundai Engineering and Construction Company Ltd which was the main contractor of this bridge.

Hyundai worked together with Syarikat Pembinaan Hashbuddin (M) Sdn Bhd, Lim Kar Bee & Sons Sdn Bhd and Syarikat Pembinaan Rahim Sdn Bhd on packages 3 to 7 of the bridge. Package 1 was undertaken by Loh & Loh Construction Co Ltd and Package 2 by Maraputra Sdn Bhd.

The main consulting engineers Howard Needles Tammen & Bergendoff international Inc and Jurutera Konsultant (SEA) Sdn Bhd worked with Yong & Mohd Faiz Sdn, Kumpulan Arkitek Sdn and Valdun Associates Sdn Bhd.

The project led to the establishment of training schools which benefitted many Malaysians who trained and upgraded their skills and craftsmanship in these establishments.

The site for the Penang bridge was a challenge for contractors as it is on soft ground.

This would result in an embankment of 7.5m high settling at 1.2m during construction, and a further 1.9m five years after construction.

However, this was overcome with the introduction of latest technologies in the design and construction of Penang Bridge.

The bulk of materials used for the project include locally sourced and produced cement, sand, coarse aggregates, steel reinforcement bars, timber and natural rubber bridge bearings.

Among some of the considerations made in the design and construction of the bridge was the possible impact of seismic activity in the region on the structure, because although Peninsular Malaysia is regarded as a stable area it is still flanked by active tectonic areas to the west and south.

The nearest fault line to the bridge site is 70km away. Thus, in order to restrain the orthotropic bridge deck against horizontal movements in excess of desirable limits, reinforced shear blocks are incorporated in the design. Penang Bridge bridge is designed to withstand a 7.5 magnitude earthquake on the Richter scale.

Also owing to the variation of soil conditions in the construction area, the project area was divided into a number of characteristic soil units. Preliminary pile load tests were done in each of these, and the length of piles for each unit was determined by the preliminary pile load tests.

With 3 interchanges, the Penang Bridge of which 8.4 km is above water has 533 spans of which 192 are above water. Four towers in the mid span area are 101.5m tall and 33m above water.

Facilities and amenities on the bridge include 24-hour closed circuit television (CCTV) camera installed at seven locations along the bridge, laybys, 12 emergency telephones (ET) which are located along both the Penang and mainland bound route at 1.2 km intervals on bridge laybys and the main span. The bridge is also equipped with Variable Message Signages (VMS) ■

Petronas Twin Towers

A towering beacon that propelled Kuala Lumpur into global attention and convinced businesses and investors of the potential in this nation as it charges towards developed status in the year 2020.

With the Government's decision to relocate the Selangor Turf Club to Sungai Besi in the outskirts of Kuala Lumpur (KL) in the early 1980's, an opportunity to redevelop the prime 100-acre site into a world class city centre presented itself.

Then Prime Minister Datuk Seri (now Tun) Dr. Mahathir Mohamed envisioned a development that would be distinctive enough to draw global attention to Malaysia and investors to the country.

An international competition was held in 1990, and the winning Masterplan design was submitted by Klages, Carter, Vail & Partners of USA (KCV).

It outlined a "city-within-a-city" sustainable development concept on a 37 acre site. This included components such as office buildings, hotels, residential and retail spaces, and a 50-acre park designed by the late Robeto Burle Max, a renowned Brazilian landscape artist.

Petrolium Nasional Berhad (PETRONAS), Malaysia's national oil company, was at that time, looking for a new headquarters to merge its KL operations (which at that time was scattered throughout the city in 14 different locations) under a single roof. The Northwest corner of the new development, flanked by Jalan Ampang and Jalan P. Ramlee was ideal for this purpose.

In January 1991, PETRONAS took majority stake in KLCC development, capitalising on the opportunity to relocate its operations to a single, high-rise building, thus sealing its involvement in the Masterplan and subsequent design stages.

That same year, Caesar Pelli and Associates (CPA), a USA-based architectural firm, was appointed to design the first phase of the KLCC project, through an international competition. This included the USD1.6billion, 88-storey PETRONAS Twin Towers, a unique skyscraper unlike any other at that time.

The design brief, amongst others, called for efficient utilisation of space, maintainability and a modern intelligent building management system - in essence, a state-of-art office building that would become a benchmark for other developments in KLCC.

It was important that the project had a Malaysian identity, not only through the use of materials but in both shape and character of the buildings.

The Twin Towers are the world's renouned landmark for Malaysia


4:12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CPA conceptualised the floor plates of the towers based on geometric patterns prevalent in Islamic architecture. The floor plates were derived from superimposed, rotated squares with small circular infills around the edges. These geometric figures were described by the architects as "symbolizing unity within unity, harmony, stability and rationality" – all of which are important principles in Islam.

The lobby designs incorporated contemporary Malaysian motifs adapted from traditional handicraft such as Songket and timber carvings. The floor was laid out in Terengganu Green and Melaka Beige granites in a stylish 'Mengkuang' weave mat design. The marble mosaic wall of Langkawi red and white resonated a distinct Pandan weave design. Carved wood screens were adapted from timeless patterns visible in villages all over Malaysia. Each panel is a single piece of carved Nyatoh wood.

Kuala Lumpur City Centre Berhad (KLCCB) was formed in 1992 to develop and project-manage the PETRONAS Twin Towers and other Phase 1 developments within the KLCC Precinct.

An initial project management team was established in 1992 comprising of eight members from KLCCB and a number of Lehrer McGovern Group managers.

A target was set for the budget, and the project team worked in accordance with the set figure, making use of a computerized cost management system that ensured every procurement was within budget.

With close monitoring and control of construction, KLCCB together with both main contractors were able to identify the potential problems early, and plan alternative solutions to minimise if not eliminate any delay altogether.

The contract for Base Building works were awarded to two consortiums namely Mayjaus Joint Venture (comprising Hazama Corporation, JA Jones, MMC Engineering, Ho Hup Construction and Mitsubishi Corporation) for Tower 1; and SKJ (comprising of Samsung Engineering and Co, Kuk Dong Engineering and Construction and Syarikat Jasatera Sdn Bhd) for Tower 2 and the Skybridge.

The PETRONAS Twin Towers' site was a flat greensward, but the result of soil probes proved that the bedrock pattern underneath was similar to that in most areas of the city centre i.e. extremely irregular. Such conditions require substantial treatment and additional work for the towers to be properly supported. This would not permit the original design objective to be met at a reasonable cost. Thus, the location of the two towers were shifted 50 meters south-east, where the thickness of the Kenny Hill formation overlaying the limestone bedrock was sufficient to support a raft on bored friction piles.

Following excavation work 20m below ground level, friction piles were then constructed and a 4.5m thick foundation raft poured. A total of 13,200 cubic meters of concrete per tower was cast in a single pour over 54 hours to eliminate construction joints in the pile raft. This was the single longest concrete pour for a building foundation. The overall construction for this foundation package took 12 months to complete.

During the design stage, KLCCB together with consultants reviewed and evaluated five different systems for the structural framing of PETRONAS Towers. The team finally recommended a composite system that exploited the advantages of both steel and concrete, to meet the challenge of constructing a 455m tall building.

Among the advantages of this composite system is the fact that local contractors were familiar with the use of concrete for both the column and corewall of the PETRONAS Twin Towers, not to mention its easy availability at lower cost.

Furthermore, concrete could be easily pumped up to the work site without the need for massive cranes, and be molded into even the most complex shape. It also helped curb natural way movement as its ability to attenuate movement is twice that of steel.

The concrete strength used varied from grade 80 at lower floor up to grade 40 at upper floors. In total, about 800,000 cubic meters of concrete, reinforced with 30,000 tons of steel beams, trusses and reinforcement were used for the construction of each tower.

The Twin Towers were cladded with 33,000 panels consisting of 83,500 square metres of stainless steel extrusions

Both main contractors carried out concreting and structural works on a 24-hour basis. At the peak of construction, each floor was completed in an average of four days. This was a tremendous achievement not only for the main contractors but also for KLCCB.

The external cladding of the towers saw the transfer of new technologies into the country, as well as the optimisation of the use of local expertise and materials. The contract was awarded to a consortium of Harmon Contract Asia Sdn Bhd, Lucksoon Metal Works and Nippon Light Metal (HLN) in 1994 which was subsequently incorporated into the contract of Base Building Main Contractors as a Nominated Subcontractor (NSC). Being NSC, both main contractors i.e Mayjaus and SKJ were responsible to manage HLN in the construction of the external claddings of the towers.

Altogether, the PETRONAS Twin Towers are cladded with 33,000 panels consisting of 83,500 square meters of stainless steel extrusion and 55,000 square meters of custom made 20.38mm laminated light green glass, the first ever being used for a building in Malaysia.

The skybridge is an essential and functional component of the PETRONAS Twin Towers that links the sky lobbies of both towers at level 41 and 42. In addition to its primary function as a circulation interchange between the two towers, it also acts as an emergency exit options in the event of a fire. It facilitates evacuation from the upper floors of one tower if the emergency is confined to one tower. The skybridge which is located at 170 meters above street level, spanning 58.4 meters and weighing 750 tonnes was fabricated in pieces by Samsung Heavy Industries in South Korea.

The design of the skybridge was carried out by the Engineering Consultants, Thornton-Tomasetti in association with Ranhil Bersekutu Sdn. Bhd. through various design and structural options using the state-of-art computer simulations and wind tunnel testing.

The bridge structures were pre-assembled in five sections at the Concourse Level of the tower link, the area in which construction period was purposely delayed to allow for adequate space to assemble the skybridge structure. The five sections of the skybridge were lifted in sequence beginning July 6, 1995 before being fully installed at the designated locations in early August 1995. This mammoth exercise was completed in an operation that took 32 hours. The skybridge is fitted with damping devices in both legs to reduce movement which could cause fatigue cracking at some welded joints.

The skybridge – a major tourist attraction, links the sky lobbies of both towers and act as an emergency exit option

Similar to the skybridge, the pinnacles presented another major challenge in the construction of the PETRONAS Twin Towers. Each 73.5m high and 180 ton the pinnacle consists of three main components namely, the mast, a 2.6 diameter ring ball, located at the mid section of the mast and a 1.9 diameter of spire ball at the top of the mast. Prior to the actual lifting and installation at site, the erection procedures which was mainly using a hydro-jacking system were carefully studied, evaluated and agreed on by all parties involved.

The towers were designed to withstand wind speeds and loads up to 135kmph, and a Zone 4 or magnitude 5.4 earthquake on the Ritcher Scale.

The PETRONAS Twin Towers were top-out in February 1996, marking the completion of the superstructures.

The management team of the PETRONAS Twin Towers constantly explores opportunities to address issues on improvements, enhancements, upgrades and obsolescence to ensure that the towers remain efficient, up-to-date and as impressive as when it first became operational. The PETRONAS Twin Towers has to date attained the Provisional Gold Certification under the Green Building Index Malaysia and will continue to expand on green initiatives ■

Putrajaya

Perdana Putra, the office of the Prime Minister of Malaysia, is built in the heart of Putrajaya

Built to replace the government administration buildings in Kuala Lumpur, this administrative capital showcases the capabilities of Malaysian design and construction industry experts who teamed up to build a city that is unique and identifiable to local and Islamic cultures, using innovative engineering tools and methods to deliver a smart city that is stunningly picturesque and traditional, yet geared to face the future with the latest in terms of technology and innovation.

The beginning

Plans for a new administrative center outside Kuala Lumpur (KL) started making its rounds in the 1970s during the tenure of the late Tun Abdul Razak Hussein as Prime Minister. The capital city, once a colonial outpost, was beginning to show signs of strain from rapid urban development following the country's shift from being a commodity-based agricultural economy to a manufacturing-based export economy.

It was during this time that then Prime Minister Datuk Seri (now Tun) Mahathir Mohamad revived plans for a separate administrative capital and in 1992, a study commissioned by the federal Economic Planning Unit recommended that the federal administration shift its offices out of KL.

The projected growth rate of government personnel called for more office space and accommodation. The government was short of land in KL where land prices and rental rates were at a premium.

Also taken into account were the social and environmental costs arising from higher traffic volume in the city. In addition, it was more cost efficient and convenient to build up growing information technology facilities and networks from 'ground zero' for a more 'wired' government.

Site identification

Eight areas were identified as possible sites for the shift. In 1993, Prang Besar in the Sepang district of Selangor was officially declared as the spot for the new administrative capital of the country. This location along the new growth corridor was ideal, and would make the land acquisition process easy since Golden Hope Plantations, a subsidiary of Permodalan Nasional Bhd occupied the area.

It was at that time an oil palm plantation and research facility.

In Oct 1994, Prang Besar was renamed Putrajaya in honour of the first Malaysian Prime Minister Tunku Abdul Rahman PUTRA Al-Haj.

The Putrajaya mosque looks regal at sunset against the backdrop of Putrajaya's 650 hectare's man-made lake

Stakeholders

The role of planning this project was awarded to Konsortium Perang Besar, a consortium of master planners made up of the Department of Town and Urban Planning Peninsular Malaysia, the Public Works Department and Kumpulan Perunding Kota Bistari Sdn Bhd, which is made up of six private consultancy firms: Akitek Jururancang (M) Sdn Bhd, BEP Akitek Sdn Bhd, Hijjas Kasturi Associates Sdn Bhd, Minconsult Sdn Bhd, Perunding Alam Bina Sdn Bhd and Rekarancang Sdn Bhd.

On Oct 19, 1995, Putrajaya Holdings Sdn Bhd was incorporated to fund and construct government buildings, civil staff quarters, commercial and private residential premises, and infrastructure for these.

It was made up of national oil company Petrolium Nasional Bhd (PETRONAS) (40%), government investment arm Khazanah Nasional Bhd (20%), and the national trust fund Kumpulan Wang Amanah

Negara (20%). Putrajaya Holdings became the government appointed concession holder, landowner and master developer of Putrajaya.

Putrajaya Holdings localisation program ensured that 99% of Putrjaya's development was in the hands of local consultants, contractors, technical specialists, management experts, artisans and skilled workers - keeping costs low.

Foreign input was restricted to the construction of the mosque, wetlands, Light Rapid Transit (LRT) tunnel and interior decor of special spaces.

Raw materials were mostly locally sourced, from granite and reinforced concrete to timber and steel.

This and the fact that its financial commitments were with local financial institutions, helped ensure that Putrajaya Holdings was able to keep its head above water during the 1997 Asian Economic Crisis, deliver the project on time, and help sustain the construction industry.

Fusion of Heritage Inspired Architecture and Modern Construction Technology

The brief given was: to draw up a masterplan for a timeless Islamic-inspired heritage city on 4,931ha of land.

The main axis of the city is The Boulevard. Being the main feature and thoroughfare of the government administration center, this part of the city had to be visible and prominent.

It was originally stretched along the entire length of Precinct 4, astride a platform of around RL24.00.

Unfortunately, this meant that it was only visible in its home precinct.

Thus, the masterplan had to be reviewed and the Boulevard realigned and extended from 2.1 kilometers to 4.2 kilometers, bisecting the Core Area.

This way, the arterial road becomes the central spine of the city that draws the core areas of Precinct 1 - 5 together- making it a cohesive city center.

This realignment also meant that there were uninterrupted city views from various locations around Putrajaya. This aesthetic improvement was also a boost to the real estate value of the city.

In addition to this, the decision to realign the masterplan also meant that mounds in the natural terrain were retained leading to savings from the reduction of earthworks.

Also realigned together with the Boulevard were the offices and residence of the Prime Minister which had to be relocated along the axis of the Boulevard.

One feature that most first time visitors to Putrajaya will be drawn to are the domes on landmark buildings in that city like the Prime Minister's office (Perdana Putra), the Prime Minister's residence Seri Perdana, the Putra Mosque and the Palace of Justice.

Seri Perdana's singular 10m dome is Malaysia's first composite dome; manufactured and installed in 1998, while Putra Mosque's majestic tiled dome measuring 50m from the tip to the finial was manufactured and installed in two months.

Employing German composite dome construction technology, these domes were built using composite, a glass fiber fabric mixed with epoxy resin composite shell panels that are stronger, more durable and incredibly lightweight (between 10 to 15% the weight of a conventional concrete dome).

It is also easier to incorporate intricate designs and tile work on composite domes, as the embellishments can be fabricated with factory controlled precision on the ground.

The domes of Putrajaya sport glass mosaic tiles that are durable and corrosion-free, providing the best external finish.

The tiles are bonded and grouted to the composite shell using an epoxy-based adhesive.

Since the tiles and shells have similar coefficient expansion, the bond is not stressed and therefore long lasting.

The dome shells are subdivided into large prefabricated panels, to facilitate rapid on-site installation. About 30% less time is used to install these technologically advanced domes.

Furthermore, no scaffolding is required for the installation of the self-supporting dome shells.

Perdana Putra, the Prime Minister's office with the green dome, in the middle of the administrative center features several symbolic elements like the two hectare perimeter base that is symbolic of a strong and efficient administration for the country, while the series of columns depict upstanding citizens supporting the sovereignty of the nation.

The east and west blocks are topped with the traditional Malay pitched roof, with hips and gable ends, suitable for the hot, humid and rainy climate. The main block is topped with the Islamic inspired green dome - symbolising the upholding of laws of the nation, and of that of God with regards to matters of the state.

The high structure provides good ventilation while the orientation of the building along the north-south axis optimises the use of natural light within the building.

The brown and green colours used, complements the natural environment, while the texture of different building materials adds variety.

Traditional Malay motifs are used to soften the facade, while a stylised hibiscus wrought iron climbers spiral up four storeys of the main block's north and south entrance - lending it a dramatic effect.

Perdana Putra has five entrances and is designed to be accessed via road, water and rail.

Similarly, the Putra Mosque and its Persian inspired design, has a commanding presence in the administrative capital with its reinforced fiber glass dome, elaborately inlaid with pink and beige mosaic tiles.

Columns in the mosque are embellished with polished granite cladding, while there is extensive use of stained glass adorned with Islamic motifs.

Master craftsmen from Morocco were responsible for the decorative and Quranic verses on the gypsum ceiling, while local master craftsmen concentrated on the 'cengal' hardwood and decorative panels around the mosque.

Seri Perdana, the official residence of the Prime Minister on a 17.2 hectare site in Putrajaya distinguishes itself from other building in the city with its tranquil backdrop on the crest of a mound on the Putrajaya lake.

This building is divided into three blocks that are linked by a series of 'selang' or passages. Each block has clearly defined functions.

- Main reception/protocol block is the formal reception area
- Banquet block is for formal receptions. These two blocks are open to the public for guided tours.
- Residence block where the Prime Minister and his family lives

Height variations caused by the sloping site where the highest point is 70m and the lowest 21m were resolved by creating a series of terraces.

This minimised the need to alter the undulating topography and in turn resulted in a multi-tiered structure, commonly found in traditional Malay houses, whereby each level has its own function.

The building sprawls into beautifully landscaped gardens with a view of the city.

The traditional Malay features of arches, windows, doors, v0erandahs and passages are visible throughout.

While it features Malay and Islamic designs, this building also incorporates western and contemporary elements like its French inspired interior decor.

Planning, security and privacy were over-riding considerations in the development of Seri Perdana. Guided tours are restricted to certain areas only.

Among the government blocks, the red brick Parcel D Complex is the most eye catching. It won the prestigious Malaysian Construction Industry Award 2000 (Contractor Award for Large Scale Project) for its architecture and engineering. This building required specialised brick-laying skill that was provided for by the Malaysian Construction Industry Development Board.

Smart Solutions

The Putrajaya Hospital is a smart hospital managed by the Total Hospital Information System, while three smart schools constructed by Putrajaya Holdings and handed over to the Education Ministry were equipped with labs, internet connection and computers for students and academic staff.

Homes in Putrajaya lead the country in terms of internet connection facilities. Once wired, residents can with the aid of a personal computer, telephone, control panel and smart card, link and operate home appliances like televisions, vacuum cleaners and microwave ovens remotely.

These smart homes are also wired to allow their owners to regulate usage of air-conditioning and lighting, thus saving on energy. Despite no fences, these houses are equipped with 'personal to user' card and voice recognitions systems.

An interactive television system and remote control also connects homes in Putrajaya to the police, hospital, fire station and other emergency services.

Barrack style housing was avoided in favour of homes that were more suited for local weather.

Transport

In terms of transport and connectivity, there are three main modes of transport - road, rail and water with much emphasis on reducing the number of road users, traffic congestion, stress and pollution. There are several 'Park and Ride' facilities that allow users to park and board public transportation to their destinations in Putrajaya, in addition to bus terminals and waterfront precincts for water-taxis.

Putrajaya Sentral is the transport hub where commuters can hop on the Kuala Lumpur International Airport (KLIA) Transit to head to KLIA or KL Sentral in the city.

Well connected roads, walkways and elaborate street lamps are part of this city's highlights.

Care for the Environment

A lot of attention has been paid to maintaining green areas, landscaping and pathways for parks and recreation in Putrajaya. There are 12 parks throughout the city that form a green corridor.

Taman Wetlands that adjoins Putrajaya Wetlands also provides an idyllic recreation, education and research spot. These wetlands also act as a filtration system to treat catchment water flowing into the Putrajaya lake which is used for water sports and recreation.

During construction, an environmental management unit was set up to enforce workplace environmental rules and regulations, and implement this towards building an environmentally sustainable city.

The design of the Putrajaya International Convention Centre is based on the shape of the Pending Perak, a silver Malay royal belt buckle


PUSAT KONVENSYEN ANTARABANGSA PUTRAJAYA
PICC

Beautiful Bridges

The master plan for Putrajaya included a 400-hectare lake surrounding the island that would allow accommodate plans for recreational facilities, water sports, boat races, fishing and other outdoor activities. Eight bridges were built to connect this Core Island to the mainland.

There are three type of bridges in Putrajaya, and the single difference between the three is the distance that can be supported in a single span. Two main issues taken into account when constructing the bridges were how well these hold up and the engineering capability to take on the weight of traffic and users, in addition to architectural and aesthetic considerations.

Four of the eight bridges belong to the beam tradition - the Putra Bridge, Seri Perdana, Seri Bakti and Seri Setia bridges; two are of the arch type - the Seri Gemilang and Seri Bestari bridges; while the Seri Wawasan and Seri Saujana bridges both employed the cable-stayed principle.

These bridges come with unique features and serve a multitude of purposes - for traffic, for pedestrians, cycle tracks and tunnels for future rail systems.

The Putra bridge incorporates Iranian architecture, Seri Perdana although simple features clever tile-work in patterned yellow hues.

Similarly the Seri Bakti bridge uses aesthetics to reduce the harshness of the concrete structure like the minaret type observation decks with dome shaped roofs, decorative railings and lamp posts and planter boxes with Durata Gold and Canna Generalis flowers. The Seri Bakti bridge's interesting feature is in it's tapered piers built in sets of four that gives an illusion of a floating hallway on the lake. This bridge also features tropical themed landscape on an around it.

The Seri Gemilang Bridge was built to impress visitors as it leads up to the Putrajaya International Convention Centre, Dataran Gemilang and the Putrajaya Boulevard. It is also designed in honour of then Prime Minister Datuk Seri (now Tun) Dr Mahathir Mohamad who was impressed by the Pont Alexandre III bridge in Paris, France. The local design however concentrated on intricate architectural features and finishings, and did away with figurative decorations to keep in line with the Islamic theme. The arched Seri Bestari Bridge on the other hand is more functional with a deck width of 27m consisting of dual two-lane carriageways, cycle track cum pedestrian walkway and a central median. The unique proposition of this structure is the aesthetically slim and transparent arches beneath the bridge.

Both the cable stayed bridges in Putrajaya are unique in terms of design. The primary function of the Seri Wawasan Bridge is to facilitate travel across the lake, but due to its high visibility location was classified under the identity bridge category. The inspiration for the design of this bridge is a sailboat. The single span structure has a single inverted 'Y' shaped pylon inclined forward at 15 degrees to the vertical axis, and it soars up to 96.6m towards the centre of the span. The main span is supported by 30 pairs of front stays arranges in the shape of a fan.

The stay cables gives the illusion of boat sails being blown by the wind.

Twenty one pairs of back stays crisscross on the other side. This balances the forces holding the bridge together. Each stay has between 13 and 125 strands, with a 15.7mm diameter each.

The unique stay arrangement enhances the aesthetic impression of the bridge, besides providing stability and support.

Wawasan Bridge

Seri Saujana Bridge

One of the significant processes in the chronology of this bridge is the casting of the pilecap which was cast continually for 53 hours with 3,664 cubic meters of concrete, creating the record for the largest single mass pour in Putrajaya.

The Seri Wawasan Bridge is the first to be built with the stayed cable technology in Malaysia.

To ensure the durability and safety of the structure which has the largest anchorages ever built for any cable stay bridge, two full-scale fatigue tests were carried out for the stay system subjecting two million cycles of repeated loads. The test for the 125 strand anchors created the record of being the world's largest scale test of its kind at the time of the testing in 2001.

The Seri Saujana bridge is Putrajaya's signature bridge, the first to successfully combine two different engineering techniques - arch and cable-stay to produce a hybrid. On record, there is no other bridge structure like it in the world. Despite doubts among the engineering fraternity on merging two different and opposing building techniques, designers of this bridge challenged conventions and triumphed.

Engineers formulated the design from scratch and combined fundamental engineering principles with the use of computer design modelling techniques.

Virtual reality prototyping was used to create aesthetic designs, structural analysis and fabrication. This enabled designers to assess the implication of design decisions and refine specifications. High standards of production evolved from the accuracy and completeness of the fabrication information.

Only 15% of materials were imported for this project, this included the patented cable stay anchorage system and the Grade 50B steel plates used for the arches and pylon heads.

Due to its immense size (Diameter 2.10m with wall thickness 40-61mm), each arch was fabricated into 19 connecting segments and transported to site and welded in-situ

The rolling and assembly of arches, and pylon head steel shell fabrication were carried out in Ipoh and Lumut, while the stay cable strands that were individually wrapped and greased in HDPE for corrosion protection, were produced in Shah Alam, while the outer HDPE pipes for the stay cables were manufactured in Klang. Prestressed concrete curved multi-cellular box girders were cast on site to construct the deck.

Putra Bridge

Two backward inclined pylons shaped like the traditional Malay sword were constructed at both ends of the bridge to act as towers for fixing the stay cables.

The lower segment of the pylon is made from reinforced concrete sections constructed by climbing formwork.

The upper section that holds the cable anchorages, is constructed from composite and its external structural steel shell filled with reinforced concrete.

To ensure accurate positioning of anchorages and stay cable guide tubes, the pylon head steel shell is fabricated as a single unit, cut into nine modules for transportation and re-assembled at site.

Twelve stay cables are arranged in a fan system from the pylon head to the bridge median. The tension forces of the front cables are dissipated with two rows of backstays made up of 10 cables each at both ends of the bridge.

Static counterweight boxes are then used to balance the uplift forces of backstay cables. In many bridges, large concrete blocks or ground anchors are commonly used. The Seri Saujana builders, however took advantage of the final road elevation and filled concrete counterweight boxes with earth.

This innovative decision resulted in an economical, reliable, maintenance free and effective counter-weight solution for the bridge.

A pair of steel arches 220 meters long and 34 meters high at its apex spans this bridge. The width between the two arches narrows up towards the vertical axis, resulting in a three dimensional hyperbolic arch. Horizontal 'K-bracing' made from steel pipes are connected to the steel arches to stabilise the structure.

The two arches are anchored onto four buttresses at the abutment. The buttresses are subsequently cast after arch alignment.

A total 23 hangers are suspended from each arch. Each hanger is made of 4-6 strands of 36mm high tensile bars and encased inside a steel tube in-filled with cement grout.

No bearings or expansion joints were used for this bridge, creating an almost maintenance-free structure. The temperature variations, which are limited in this climate, can also be easily taken care of by the controlled vertical displacement of the deck.

The creep of pylons due to the sustained stress from the cables and its influence on the cable forces is also easily adjusted simply by monitoring and re-stressing the cables whenever necessary and such procedures have been allowed for in the anchorages detailing (provision of a stressing nut).

Seri Gemilang Bridge

New beginnings

On June 21, 1999, Dr Mahathir and staff of his department moved to their new administrative center at the Perdana Putra building in Putrajaya- a far cry from the wooden structure from which the first Prime Minister of Malaysia Tunku Abdul Rahman led the country.

They were the first of the government ministries and agencies to move to the new administrative capital, the rest followed suit over the years.

Mahathir said, Putrajaya is a living testimony of Malaysians capabilities, having progressed from building houses and townships to full-fledged world-class cities, utilising the rich resources at home, and expertise and experience gained from years of nation building ■

The Palace of Justice

The Palace of Justice was built with Indian, Moorish and Palladian architecture styles

The Palace of Justice (PoJ), Malaysia's new courthouse complex in Putrajaya is one of the more notable structures along the main Boulevard of Putrajaya's civic and cultural Precinct - Precinct 3.

Its Moorish domes, columns and arches exude Islamic, Malay and universal design influences that are grounded on three simple principles that represent the nation's judicial system- balance, fairness and strength.

This philosophy is symbolically represented inPoJ's architecture. Construction of this building commenced on Dec 2000 and it was completed in October 2003.

The building on a 3.3 ha land area, includes soaring columns, large interior spaces and rich Malay art deco features on the spandrels, window pediments and openings, which are adorned with traditional floral and geometric motifs.

The PoJ complex consists of a 5-storey Main Administrative block which can be identified by a high dome which signifies the laws of the nation that are subject to the laws of God.

Attached to the main block is a 2-storey satellite building that houses two federal courtrooms, six courts of appeal, 20 judges chambers and facilities like a library, banquet hall, conference hall, museum and cafeteria.

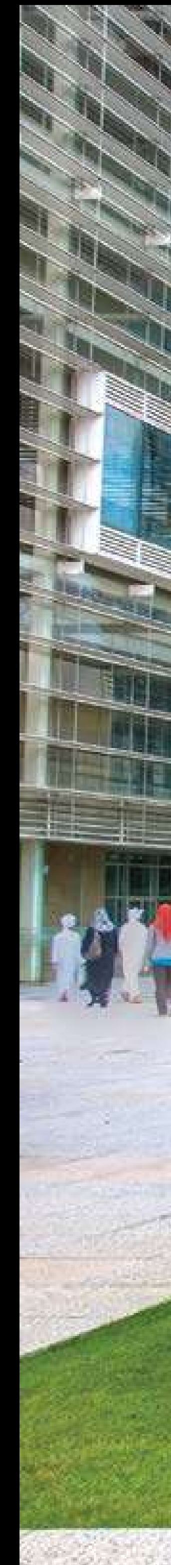
A series of double columns with muqarnas reflects an upright institution that provides justice for all.

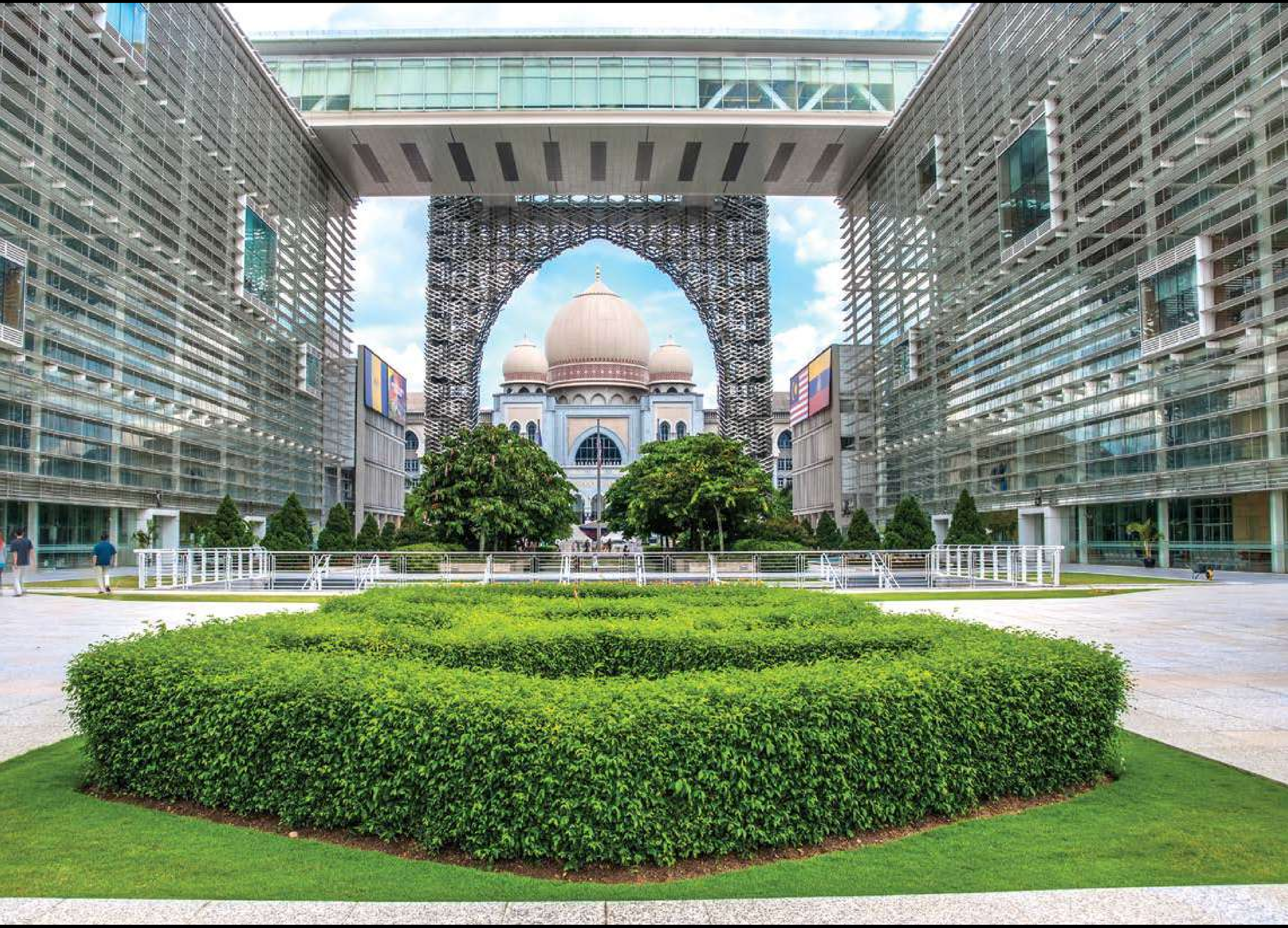
Local materials and traditional colours and textures unite the various parts of the building harmoniously.

The predominantly off-white facade signifies transparency of the courts. It sits on a dark-toned rusticated stone wall that signifies a strong and stable foundation.

The PoJ, located at the midpoint of the Boulevard, was also designed as a backdrop for national parades and celebrations - the role of the Federal courthouse complex previously located in the Sultan Abdul Samad building in Kuala Lumpur.

National day parades have been held in front of the Sultan Abdul Samad building in the capital city since independence in 1957 ■





Putrajaya Holdings Complex incorporate modern clean lines with eco-friendly features

Tuanku Mizan Zainal Abidin Mosque

This mosque in Putrajaya, dubbed as the 'iron mosque' is designed to be an attraction and beacon for the evangelization of Islam in Malaysia. The steely exterior and architecture of this mosque defies the typical Arab influence that dominates mosques the world over.

The design of the Tuanku Mizan Zainal Abidin mosque located along the main Boulevard in Precinct 3, Putrajaya is unique because it takes a bold step to depart from the predictable Arab design and architecture for mosques.Construction on the mosque that commenced in 2004 incorporates German and Chinese architecture, design and technology instead.

In place of the regular concrete structure, 70% of this mosque is built with 6,000 tonnes of steel and only 30% in concrete. It is dubbed as the 'iron mosque' or '*masjid besi*' because of this.

In addition to this, the Tuanku Mizan Zainal Abidin mosque does not have typical features of other mosques like minarets, and unlike the ornate domes of its counterparts, the dome of this mosque is made is made with rust-proof steel.

The 24m-high facade of steel with typical geometric ornamentation features rectangular openings visually connected by a filigree facade made from 4,300m² of stainless steel spiral mesh.

Each mesh element is 7.70m wide and up to 8.30m long. Joined together on site, these structures rise with the height of the facade and windows seamlessly and are secured almost invisibly using hook bolts

At night purposefully staged lighting illuminates and injects liveliness to this building.

This mosque, named after the 13th Yang di-Pertuan Agong of Malaysia is able to accommodate 20,000 pilgrims or worshippers.

The mosque is popularly known as the Iron Mosque, due to the architectural wire mesh which surrounds it

Tuanku Mizan Zainal Abidin who was Yang di-Pertuan Agong at that time, officially opened this mosque which caters for Putrajaya residents and visitors on June 11, 2010.

Constructed at the cost of RM200 million, it is designed to play a part in the evangelisation of Islam, and become an Islamic tourist destination.

One of the main features of this mosque is its 136.39m² 'Kiblat Walk' that connects the Putrajaya administration complex to the Tuanku Mizan Zainal Abidin mosque.

This mosque is designed on the three concepts - wind, moderation and transparency.

There are no fans or air-conditioning in this mosque. The interiors of the main prayer hall are surrounded by a pool and utilises the "Gas District Cooling" technology to keep the surroundings cool, and allow visitors to experience continuous fresh air and cool breezes.

A marshrabiyah screen made up of lattice surrounds the prayer hall, while a decorative metallic wailing screen allows natural light and air to flow into the main prayer areas.

The mosque is also equipped with ultrasonic technology to keep birds away thus preventing problems caused by bird droppings and nesting areas.

The unique interior design of this mosque is complemented by inscribed calligraphy from the holy scriptures of the al-Quran on 13-meter high layered glass, inspired by German and Chinese designs.

Verse 40 to 47 of Surah Ibrahim is inscribed on the right side of the mirror, while verse 148 to 153 of Surah al-Baqarah adorns the left side.

The principal gateway leading to the main prayer hall is inscribed with verse 80 of Surah al-Isra, and the white archway features calligraphy of verse 99 Asma' Ul-Husna.

One unique feature is the calligraphy of the word 'ALLAH' inside the dome when viewed from below.

The Tuanku Mizan Zainal Abidin mosque consists of five main levels, with specific facilities for the faithful and other visitors.

Ground level one (C2) is the main access to the mosque. It hosts 10 retail lots – two of which are allocated for a children's library. The multipurpose hall on this level is able to accommodate up to 250 people.

At the front of this level is a 281 bay car parking area that also provides 79 bays for motorcycles and 30 bays for bicycles.

Close to the parking area are three two-storey unit quarters for staff of the mosque, and a management office for Muslim burials.

At the ground level (C1), there are an additional 180 car parking bays, in addition to spaces for ablution rituals for male and female worshippers. Once they have completed the cleansing rituals, an escalator transports them to the main prayer hall on Level 1 (L1).

The main prayer hall on L1 can accommodate 12,000 worshippers. On both the left and right side of the main prayer hall are 'Sahns' designed to accommodate an additional 6,000 faithful. The 'Kiblat Walk' is located at this level.

At Level 2(L2) is the Terrace prayer hall that can accommodate up to 5,000 faithful is divided into two – the right for male worshippers and the left for female worshippers.

Level 3 (L3) comprises a TV surveillance and radio control room for security purposes. These facilities are also used for recording and broadcasting purposes ■

Sarawak State Legislative Assembly

A symbol of unity, diversity and sovereignty

The sovereignty of the people and rich cultural heritage of the diverse communities in Sarawak are reflected in the complex geometric design and grandeur of the Sarawak state legislative assembly building.

The Sarawak State Legislative Assembly (DUN) is the oldest state legislative assembly in Malaysia. It was set up by the state's first White Rajah James Brooke as the Sarawak General Council in 1874, and later renamed as Council Negeri (State Council) in 1903.

The new Sarawak DUN building completed in 2009 was built on the northern bank of the Sarawak river to replace the older house in the Wisma Bapa Malaysia Complex in the state's administrative centre - Petra Jaya.

Built in 1976 when there were only 48 state assemblymen, the old House had a limited capacity to accommodate the growing number of elected state representatives in Sarawak.

The RM296.5 million new DUN was designed to accommodate 108 assemblymen and serve the people and legislature of Sarawak for at least another century. The complex includes a parade ground, 315-bay car park and a landscaping.

The building was designed by renowned local architect Hijjas Kasturi with input from then Sarawak Chief Minister YAB Pehin Sri Haji Abdul Taib Mahmud.

The duo drew inspiration from parliament buildings around the world including Hungary, Italy, Austria and London – where the city grew around the British Houses of Parliament.

While the St Peter's Basilica in Rome struck the Chief Minister with its grandeur and majesty, Hijjas drew inspiration from the structural ingenuity of Europe's Gothic cathedrals and chapels.

The final design reflects the grandeur of these buildings, and incorporates the rich culture and character identifiable with Sarawak's heritage.

Its massive golden metal-clad roof is inspired by the Baruk (headhouse) roof of the Bidayuh community.

The lantern on top of the DUN building, when lit at night serves as a beacon and point of reference for the people of Sarawak – a subtle reminder of law, order, democracy, hope and faith in the future.

Nine being the largest single digit number is supposed to signify the highest form of sovereignty for the people of Sarawak and this is reflected in several parts of the DUN.

The building serves as a unique landmark located on the North bank of the Sarawak River

The roof with 18 folds – twice the key number of nine represents the duality of life inherent in the concept of Yin and Yang.

The main roof above the DUN chamber comprises two layers- the outer roof and the inner dome. Both constructed using curvilinear steel space frames.

The complex design that curves towards the pinnacle is meant to translate the concept of the people's sovereignty.

This concept is further encapsulated in the nine pyramidal roofs of the DUN building that takes on the form of a star.

The technical challenge here came from the glass curtain walling surrounding levels 7 and 9 that overhangs the nine pyramidal roofs.

Below the golden roof, the building transforms into a round neck of transparent glass designed to allow light into the public gallery – symbolising equal attention for everyone.

The building also incorporates Hindu, Chinese, Islamic and local ethnic influences, and just like the Sarawak river is a confluence of many rivers, the DUN is designed to be a meeting point for the confluence of cultures that make up Sarawak.

The intention was for the architecture to be modern in form, structure and material (concrete, glass and metal), while the eastern inspired interior aims to honour the rich culture and diversity of Sarawak.

Inside the DUN, nine pointed arches form massive super columns that support the DUN lounge and chamber 27 meters above.

The nine arches merge with floor beams to create a tree like effect – a reflection of Sarawak's rainforest heritage.

It also symbolises the people's unity and support for the government, and the democratic system it upholds.

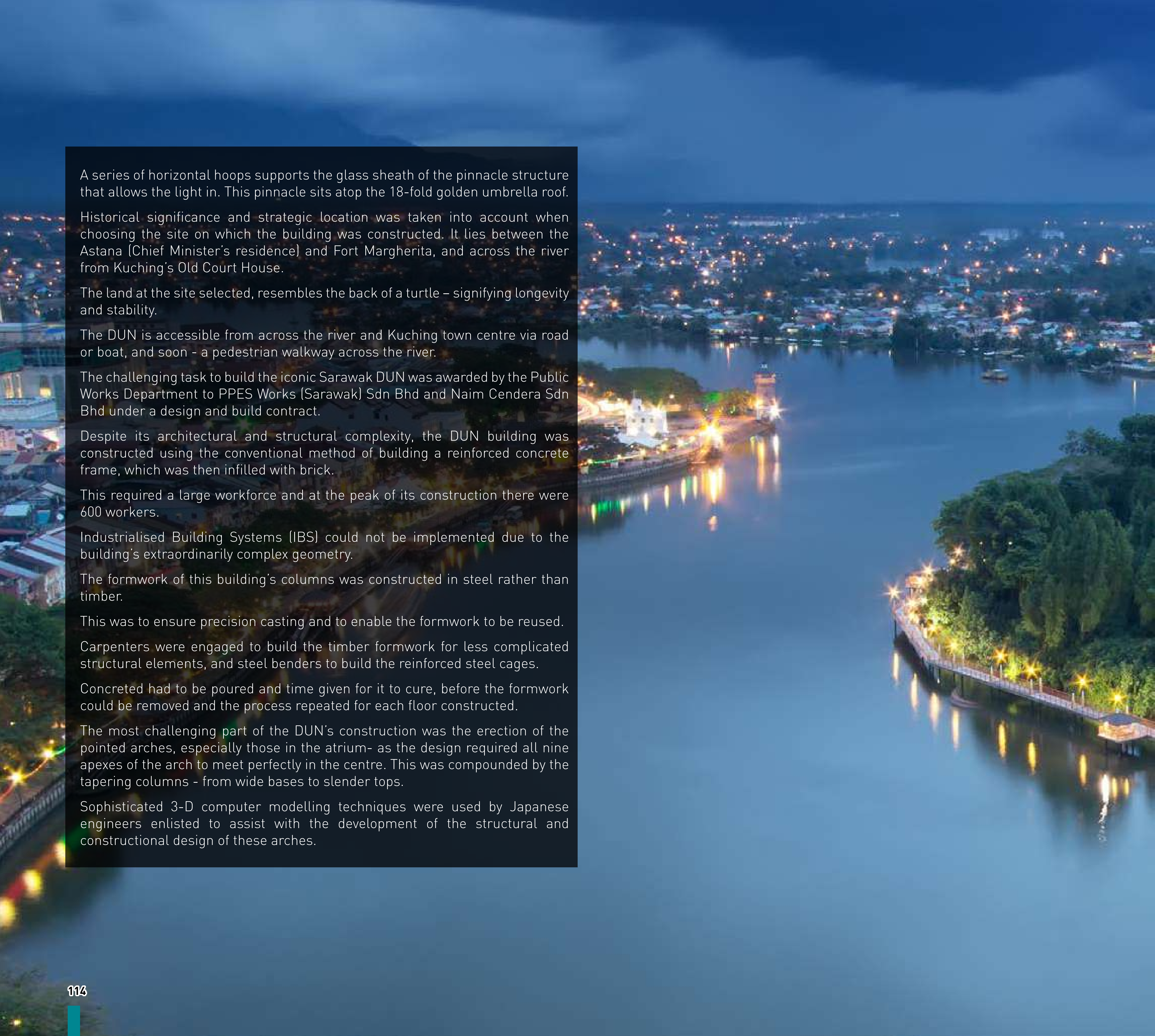
Traces of Sarawak's rich cultural history and heritage is visible all around the building's abstracted floor patterns, balustrades, wall and glass panel.

The crowning glory of the DUN is its chamber or the state legislative assembly hall which sits under a grand dome intricately moulded, and painstakingly guilded by craftsmen specially brought in from Uzbekistan.

Classically inspired, it is adorned by both Islamic and ethnic motifs - grandly orchestrated to symbolise a unified people of Sarawak.

Columns in the chamber are dressed with Songket fabric patterns, while gold mouldings in front of the member's benches are inspired by traditional Iban woodcarvings.

At the very centre of the domed ceiling is an oculus through which natural light is brought into the chamber to remind the assembly "to always be guided by divine inspiration".



A series of horizontal hoops supports the glass sheath of the pinnacle structure that allows the light in. This pinnacle sits atop the 18-fold golden umbrella roof.

Historical significance and strategic location was taken into account when choosing the site on which the building was constructed. It lies between the Astana (Chief Minister's residence) and Fort Margherita, and across the river from Kuching's Old Court House.

The land at the site selected, resembles the back of a turtle – signifying longevity and stability.

The DUN is accessible from across the river and Kuching town centre via road or boat, and soon - a pedestrian walkway across the river.

The challenging task to build the iconic Sarawak DUN was awarded by the Public Works Department to PPES Works (Sarawak) Sdn Bhd and Naim Cendera Sdn Bhd under a design and build contract.

Despite its architectural and structural complexity, the DUN building was constructed using the conventional method of building a reinforced concrete frame, which was then infilled with brick.

This required a large workforce and at the peak of its construction there were 600 workers.

Industrialised Building Systems (IBS) could not be implemented due to the building's extraordinarily complex geometry.

The formwork of this building's columns was constructed in steel rather than timber.

This was to ensure precision casting and to enable the formwork to be reused.

Carpenters were engaged to build the timber formwork for less complicated structural elements, and steel benders to build the reinforced steel cages.

Concreted had to be poured and time given for it to cure, before the formwork could be removed and the process repeated for each floor constructed.

The most challenging part of the DUN's construction was the erection of the pointed arches, especially those in the atrium- as the design required all nine apexes of the arch to meet perfectly in the centre. This was compounded by the tapering columns - from wide bases to slender tops.

Sophisticated 3-D computer modelling techniques were used by Japanese engineers enlisted to assist with the development of the structural and constructional design of these arches.

Using this design, a Malaysian steel contractor then fabricated the steel formwork in segments.

This was to allow the reinforcing steel bars to be fabricated, and the concrete placed in eight pours.

No propping was required in spite of the complex geometrical design, as the innovative formwork was designed to be supported by the reinforcing steel cage.

The steel trusses for the DUN chamber's dome ceiling and umbrella roof were prefabricated locally and lifted by a tower crane to be assembled on site.

Synergy between the construction teams were crucial in getting the job done on time and within budget. This was the key to overcoming the many challenges encountered during the construction period.

Landscaping surrounding the building is expected to help this monumental structure blend more naturally with the rest of the riverbank once the trees and plants begin to mature.

This was an important incorporation to the design aimed at giving the people a place they can relax and interact with one another ■

Sepang International Circuit

The Sepang International Circuit (SIC) dubbed as the 'Home of Motorsports' was conceived with the intention of positioning Malaysia a regional hub for motor racing activities. It was also aimed at being a catalyst to boost Malaysia's motorsports industry. This state-of-the-art circuit, was completed in a record 14 months (from September 1997 to December 1998) and officially opened on March 9, 1999 by former Prime Minister Datuk Seri (now Tun) Dr Mahathir Mohamad.

In recognition of its ultramodern facilities, this circuit was given the honour to incorporate the F1 logo in its name.

The SIC is used for annual Formula One Grand Prix, A1 Grand Prix, Motorcycle Grand Prix, as well as other major motorsports events. It also features kart racing and motorcross facilities.

From an aerial view, the circuit that covers 260 hectares of a recessed oil palm plantation valley signifies a hibiscus - the national flower of Malaysia.

This track was voted as the world's 'most challenging' track on the Grand Prix Calendar by F1 drivers in 1999.

The circuit has a double frontage grandstand overlooking the two longest straights. This can host up to 100,000 spectators. Its stadium-type concept racing circuit allows spectators to see at least 50% of the circuit from the Grandstand.

The roof of the Main Grandstand is made of textile membrane roofing material and resembles banana leaves.

The 5.542km long, 16m width track features 15 corners and 8 straights including two high-speed stretches, and the longest straight is 927m at the start-finish line.

The unique criterion of the circuit is that it can be split into two circuits when required -

the north side, and the south side with lengths of 2.8 km and 2.6 km respectively, thus allowing two races to run concurrently.

The two-storey pit building houses 30 pit garages, 15 team rooms, a race control room, time-keeping room, media centre for 600 journalists, conference room, photographers area with three dark rooms, paddocks club, management office and royal lounges.

Other components of the pit building include the Welcome Centre, Grandstand, Medical Centre with one operation theatre, and other infrastructure and safety features in compliance with FIA rules and regulations.

The RM308 million circuit was commissioned by Malaysia Airport Holdings Berhad (now Malaysia Airports Holdings Berhad) and awarded to the joint venture between Ahmad Zaki Sdn Bhd, Murray & Roberts (Malaysia) Sdn Bhd and WCT Engineering Berhad (now known as WCT Berhad).

The overall design of the Sepang International Circuit was specified by the F1 Design Consultant nominated by the Fédération Internationale de l'Automobile (FIA): Tilke GMBH (Germany) and the local lead design consultant was Iktisas Ingenieurs Sdn Bhd.

The Main Grandstand was designed and built by WCT – the main contractor.

In 1992, WCT moved out from tin mining into engineering and construction via the RM32 million Selangor Turf Club infrastructure project. In 1996, WCT successfully completed bulk earthworks of the Kuala Lumpur International Airport (KLIA) project and in 1997, WCT ventured into property development and launched the first phase of Bandar Bukit Tinggi, Klang. During this phase, WCT not only built up its expertise in infrastructural work but also amassed a growing fleet of machinery.

Good safety, quality and environmental management, industry experience and expertise in earthwork/infrastructural projects, a well-managed and committed construction team with broad knowledge and experience in engineering and construction specializing in earthworks/ infrastructure projects and a large fleet of modern earthwork construction machinery was exactly what the Sepang Circuit project needed.

The 5.543 km circuit which consist of 15 turns, are considered to be among the most challenging F1 circuits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The scope of work included earthwork (cut and fill 8,000,000m3), removal of unsuitable materials (600,000m3), landscaping and erosion control, 5.6km racing track, grandstand, pit building, ancillary buildings, concrete padlock, reservoir, sewerage system and surface drainage.

In order to retain its scenic green, more than 5,000 palm trees were planted around the circuit, and more added later.

WCT placed great emphasis on the safety and health aspects of the works, which was proven as the project was accident-free.

The track was built using a specially formulated bitumen compound, which is smooth and not too abrasive to suit the Malaysian climate and year-round use.

This compound is designated as F1 SBS (Styrene Butadiene Styrene) PMB (Polymer Modified Binder) and was developed for the extreme conditions of high-speed motor racing.

The special Polymer-Modified Binder has a significantly higher viscosity and stiffness, a higher softening point and a lower penetration point compared to other mixes used for conventional roads.

The material is 80 % more expensive than conventional wearing course mix, but it provides greater resistance to shear forces and deformation.

Smooth river stones were used for the gravel beds along the track. The stones are designed to generate as much frictional resistance as possible to passively or actively decelerate an out-of-control car, and prevent a collision with track walls or barriers.

The project faced its fair share of challenges, especially meeting the demand for specified, quality materials.

In meeting the requirements, especially obtaining materials from other countries, the contractor had to contend with foreign currency fluctuations which affected costs.

Many items needed to be specially procured. Logistics was a challenge as some materials needed to be transported to Sepang from other states/countries.

For example: The fabric material for the roof of the Main Grandstand was imported from France to Kuching, Sarawak, Malaysia to be designed and fabricated. Once ready, the items were shipped to Sepang.

Then there were the gravel beds stones that had to be the natural loose stones obtained from river or mining field. The stones are generally difficult to be procured locally as those are very selective materials.

The roof of the main Grandstand is made of textile membrane roofing material and resembles banana leaves

The 'positive kerb' and 'negative kerb' needed to be constructed in accordance to the FIA specifications.

No loose stones or aggregate can be used on the racing track to avoid the aggregate bouncing off from the track. The glass of the pit wall also has to be bullet proof in case of the above.

The coarse aggregate had to be specially ordered in the preferred cubic like shape, free from dust with good Polished Stone Value → 56. The gritstone group is excellent, with resistance to polishing being always high.

According to the strict rule set by FIA, the surface evenness may not deviate by more than 2mm over 4 meter.

Laying pattern and equipments were important thus the modern VÖGELE pavers were deployed.

VÖGELE pavers can work with a high compaction screed hence the mix had to have pre-compaction values of up to 88-92%.

Another challenge was the application of hot mix asphalt – "hot to hot" where the joint premix must be maintained at the temperature of 125 Celsius to ensure that the paved surface is smooth as difference in temperature will result in uneven joint/surface.

When paving in half moon/wide curves, just before the team of three main pavers reached a curve, a fourth machine has to place a "half-moon" which they paved alongside "hot to hot".

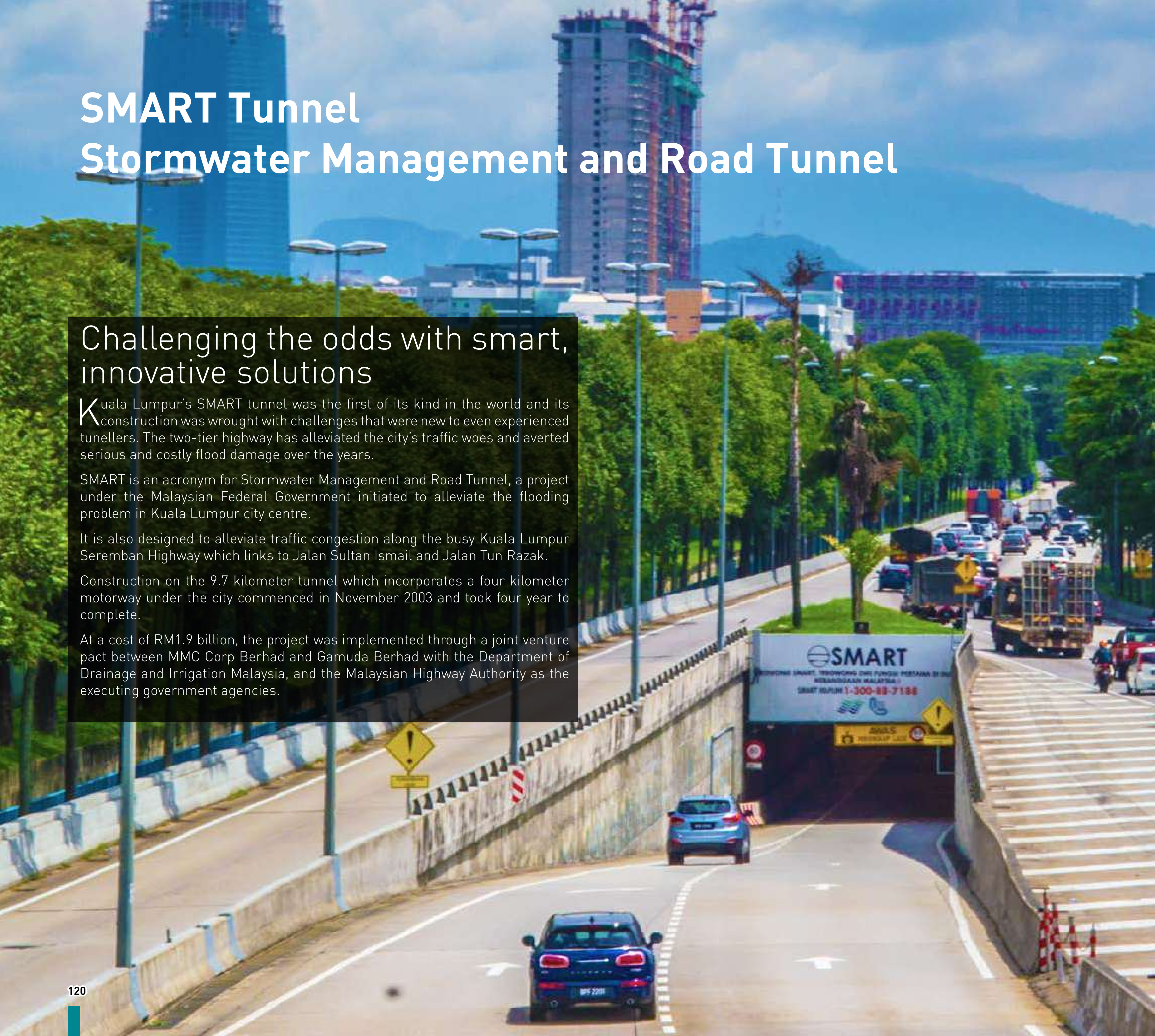
To ensure no coring on wearing course, a nuclear densometer was used to measure the density of the compacted wearing course.

Despite all the challenges, with strategic planning and determination to work round-the-clock by mobilising approximately 2,000 workers, WCT showed its mettle and delivered the project on time.

This was a significant project for WCT because it helped WCT pull through the Asian financial crisis in 1997 and 1998, and was the company's first F1 project which ignited its involvement in two other F1 racing circuits - Bahrain International Circuit, Bahrain and Yas Marina Circuit, Abu Dhabi, U.A.E.

It paved the way for WCT to become the only company in the world to have built three modern era international F1 circuits, and win awards for all three.

WCT was awarded the 'CIDB Malaysian Construction Industry Excellence Award 2001 – Special Project Award' for the Sepang International Circuit project ■



SMART Tunnel
Stormwater Management and Road Tunnel

Challenging the odds with smart, innovative solutions

Kuala Lumpur's SMART tunnel was the first of its kind in the world and its construction was wrought with challenges that were new to even experienced tunellers. The two-tier highway has alleviated the city's traffic woes and averted serious and costly flood damage over the years.

SMART is an acronym for Stormwater Management and Road Tunnel, a project under the Malaysian Federal Government initiated to alleviate the flooding problem in Kuala Lumpur city centre.

It is also designed to alleviate traffic congestion along the busy Kuala Lumpur Seremban Highway which links to Jalan Sultan Ismail and Jalan Tun Razak.

Construction on the 9.7 kilometer tunnel which incorporates a four kilometer motorway under the city commenced in November 2003 and took four year to complete.

At a cost of RM1.9 billion, the project was implemented through a joint venture pact between MMC Corp Berhad and Gamuda Berhad with the Department of Drainage and Irrigation Malaysia, and the Malaysian Highway Authority as the executing government agencies.

The expressway which was opened in 2007 is operated by Syarikat Mengurus Air Banjir dan Terowong (SMART) Sdn Bhd, a joint venture between MMC and Gamuda.

The tunnel operates on three principal modes which synergizes flood management and operation of the motorway.

The first mode is when there is no rain and no need for flood water diversion through the tunnel.

The second is when flood waters are diverted into the bypass tunnel in the lower channel of the expressway during moderate storms.

The third is when the expressway is closed to traffic during heavy storms to allow automated watertight gates to be opened, allowing flood waters to pass through. In this instance, the tunnel will usually be reopened to traffic within 48 hours.

Studies prior to construction indicated that flood prone sites in the city were the low lying areas at the confluences of Sg Klang/Sg Ampang and Sg Gombak/Sg Klang. The flow of the river here was further constrained by the Jalan Tun Perak Bridge (near Masjid Jamek) which is low.

The SMART system was aimed at diverting large volumes of flood water from entering this critical stretch via a holding pond, bypass tunnel and storage reservoir.

The aim was to reduce the flood water level at the Jalan Tun Perak Bridge, preventing spillover into the city center – a problem that plagued city folk for years during storms and especially during monsoon seasons.

SMART construction senior project manager and tunnel expert Gusztav Klados who had worked on some of the largest tunnel projects in the world, including the Channel Tunnel linking the United Kingdom and France, dubbed the SMART tunnel as one of the most challenging projects of his career.

Indeed the tunnel is a smart solution to drain storm water from flooding the city and at the same time, reduce traffic congestion to and from the city centre

Kuala Lumpur's limestone geology is full of cracks, cliffs, fissures, cavities and caves, and if the tunnel boring machines were to accidentally dig into a cave the result could be a potentially disastrous collapse of buildings above ground, and loss of lives. The fact that the tunnel was running under major parts of the city center meant any wrong move or decision would result in a major catastrophe.

The second issue was the lack of local expertise and the solution to this was to recruit crew locally and from all over the region and train them on the job. Construction work was thus slow at first as the inexperienced crew learnt how to handle two of the largest Tunnel Boring Machines (TBMs) in the world.

The two 71m Herrenknecht TBMs, weighing 2,200 ton a piece was custom ordered from Germany. Each TBM machine cost USD 25 million.

The two TBMs worked from the staging area outwards: one towards the Kerayong River and the other towards the Klang River.

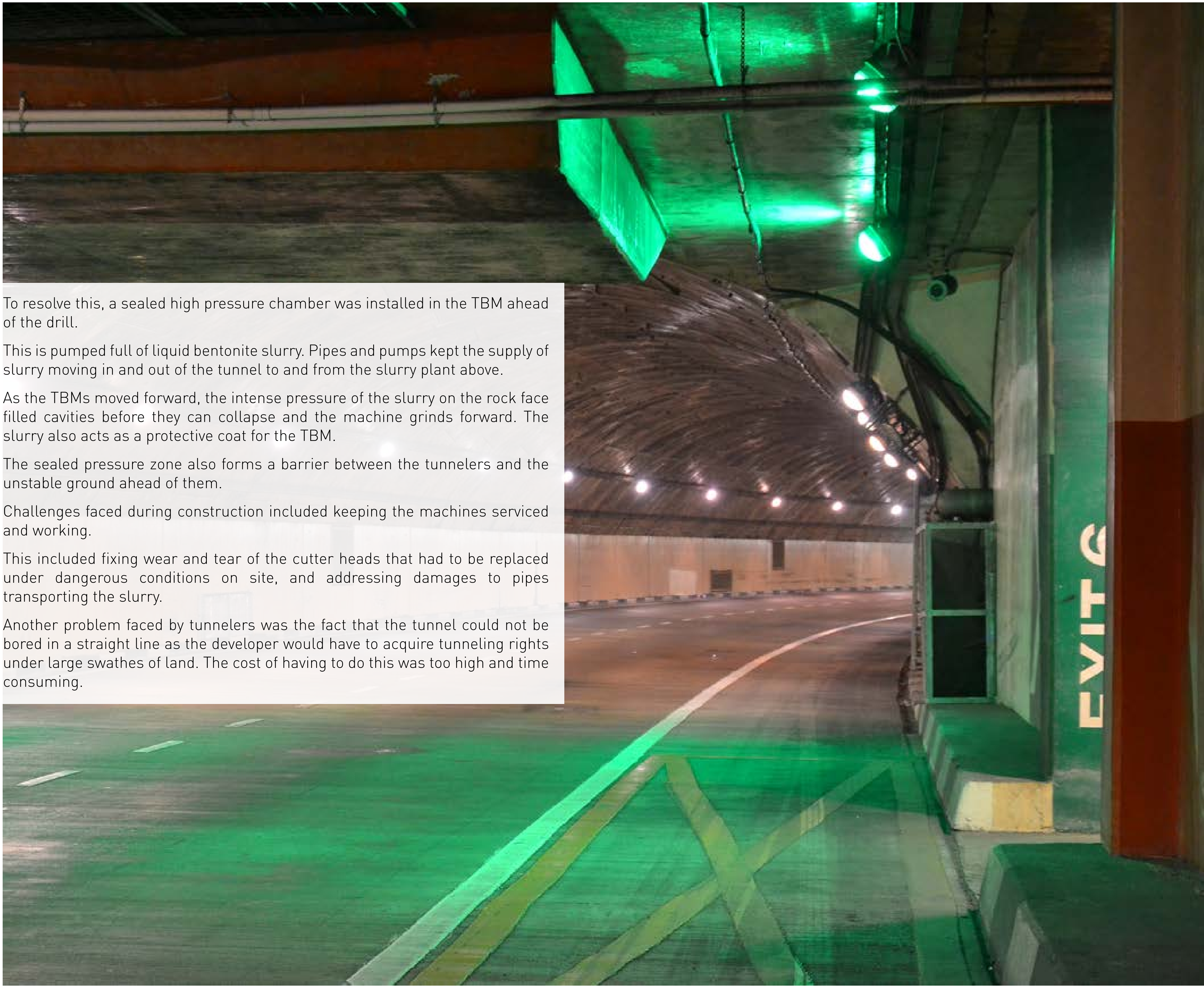
At the front of these boring machines was a 300 ton circular cutter-head forged from high tensile steel.

The function of these machines was to drill and build, and the machines chosen for SMART are specially armed to face the treacherous terrain under Kuala Lumpur – what geologists refer to as karst topography.

Surveying every single inch of the 10km stretch wasn't an option.

So to reduce the risk of collapse geologist had to probe constantly, ahead of the tunnel boring machines.

Whenever they hit a cavity they filled it with concrete based granite, but karst cavities can be less than a meter wide making it impossible to locate every one along the tunnel's entire route.



To resolve this, a sealed high pressure chamber was installed in the TBM ahead of the drill.

This is pumped full of liquid bentonite slurry. Pipes and pumps kept the supply of slurry moving in and out of the tunnel to and from the slurry plant above.

As the TBMs moved forward, the intense pressure of the slurry on the rock face filled cavities before they can collapse and the machine grinds forward. The slurry also acts as a protective coat for the TBM.

The sealed pressure zone also forms a barrier between the tunnelers and the unstable ground ahead of them.

Challenges faced during construction included keeping the machines serviced and working.

This included fixing wear and tear of the cutter heads that had to be replaced under dangerous conditions on site, and addressing damages to pipes transporting the slurry.

Another problem faced by tunnelers was the fact that the tunnel could not be bored in a straight line as the developer would have to acquire tunneling rights under large swathes of land. The cost of having to do this was too high and time consuming.

This meant that the large TBMs had to negotiate tight turns – a challenge for even experienced tunnelers.

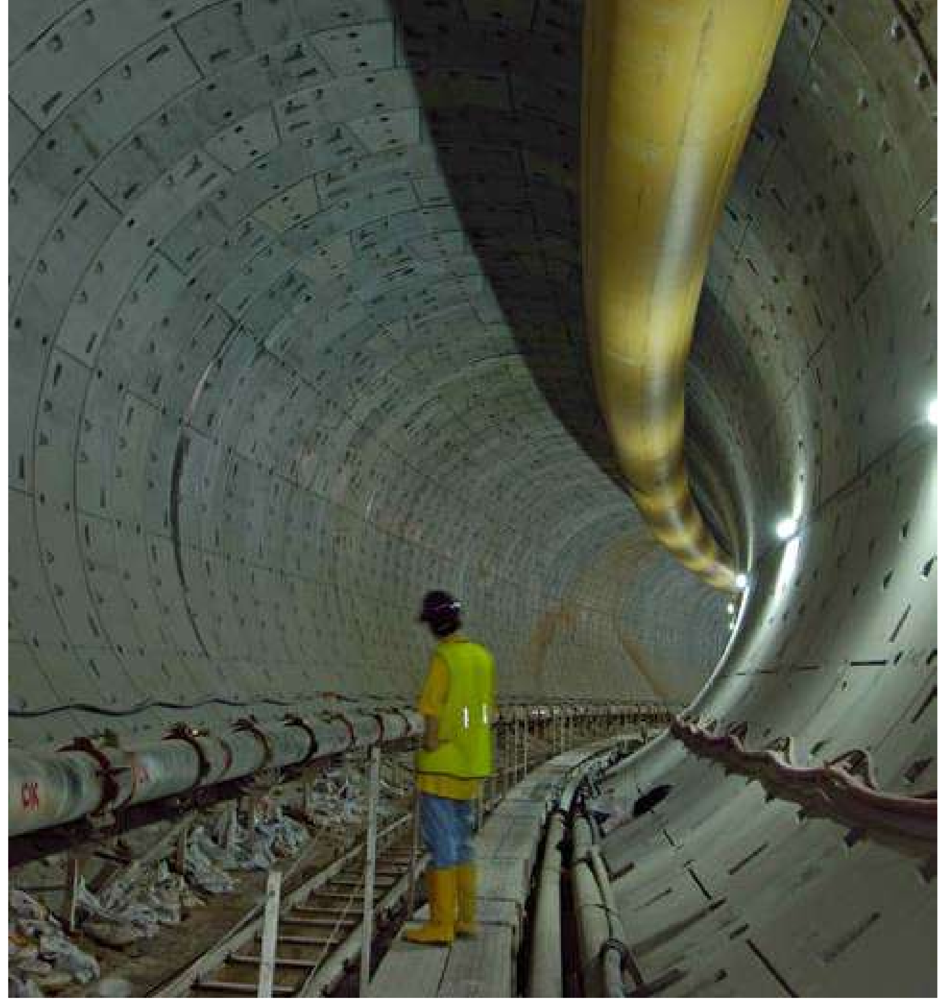
As a solution, a special giant bearing was installed at the front of the TBMs to enable the drill head to navigate the tight turns.

The concrete tunnel rings also had to be designed to fit the curving tunnel accordingly.

The teams were skilled enough to lay claim to the record breaking feat of laying up to 17 concrete rings a day using the enormous machines.

Safety is one of the key-focus of the tunnel operations. This includes a state of the art control room to monitor the tunnel and highly trained personnel to handle emergencies especially fires.

Safety features in the tunnel include lights built to withstand pressure form raging flood waters, ventilation shafts every kilometer, clearly demarcated escape routes, connected road decks every 250 meters and 24-hour CCTV monitoring ■



Sultan Abdul Halim Mu'adzam Shah Bridge

Inspiring Innovations: The Sultan Abdul Halim Mu'adzam Shah Bridge

The design and construction of the Sultan Abdul Halim Mu'adzam Shah Bridge was wrought with challenges posed by a harsh marine environment, hot climate, potential tectonic activity in the region and shallow waterways. However, it was these challenges that inspired the builders to innovate and emerge with pioneering techniques and solutions.

The second Penang Bridge, also known as Jambatan Sultan Abdul Halim Mu'adzam Shah that links Batu Maung on Penang Island to Batu Kawan on mainland Peninsular Malaysia was built to alleviate the congestion on the first Penang Bridge that links Perai on the mainland to Gelugor on the island.

The first Penang Bridge which was opened in 1985, boosted the economic activity, urban development and number of visitors to the island and mainland Peninsular Malaysia (Seberang Perai) which was only connected by ferry prior to the building of the first Penang Bridge.

However, after two decades in operation the rising number of vehicles crossing the first Penang Bridge built over the North Channel was causing massive traffic congestion.

The plan to build the second Penang Bridge, which was included in the Ninth Malaysia Plan, was announced by Malaysia's fifth prime minister Tun Abdullah Ahmad Badawi, himself a Penangite. The ground-breaking ceremony was held three months later in 2006.

It was estimated that the new bridge would alleviate traffic on the 13.5 kilometre (km) long first Penang Bridge, and was designed with a 120-year lifespan.

The 24km second Penang Bridge is the longest in Southeast Asia

The 24km second Penang Bridge, 16.9km of which is built over the Penang Strait, is closer to the South Channel and takes about 20 minutes to cross.

Recorded as the longest bridge in Southeast Asia, it was opened to traffic on March 1, 2014. This RM4.5 billion bridge merges two designs; the 16.9km box girder bridge or the approach span, and a shorter cable stay bridge called the Main Span or Navigation Span to allow marine traffic to pass below.

The Main Span, foundations and substructure were constructed by China Harbour Engineering Company (M) Sdn. Bhd. (CHEC), while UEM Builders Berhad (UEM Builders) designed and constructed the Superstructure for the Approach Span. Jambatan Kedua Sdn Bhd (JKSB), is wholly owned by the Minister of Finance Incorporated, and the company was appointed as the concessionaire to design, construct, manage, operate and maintain Jambatan Sultan Abdul Halim Mu'adzam.

The bridge was designed based on a Statement of Needs, functional parameters, load estimation, and timeframe for construction and completion given by JKSB. Construction of the bridge took just over nearly five years from June 8, 2009 until its official opening on March 1, 2014.

At every stage of the design, JKSB reviewed and approved the designs to make sure these were functional. Being a multi-party construction project lot of coordination was required of JKSB so that everything would match and fit into place.

There were some delays in the early stages, and local and foreign expertise were brought in to sort these out. Mechanisms were put in place to increase efficiency and reduce delays. In the initial stages, one of the main issues involved technical challenges in the concrete mix design that had to be strong and durable enough to withstand the harsh marine environment in the long term.

In addition to this, the building of this structure across the Strait brought with it its own environmental challenges. These included a shallow waterway, rapid siltation, structural risks from earthquakes and tsunamis.

Subsequent logistical challenges emerged involving the movement of bridge segments from land to sea, and getting them into position to be installed.

CHEC built the bridge's foundation substructure that included 5,000 piles below the sea floor, 586 piers and the cable stay bridge which required boring 120 metres (m) into bedrock, constructing 144 girders that are anchored to the road deck and stringing these through pylons that rose 90m in the air.

To strengthen the pylons, pile caps that form their base were built with giant steel fenders packed with a special concrete that can repel salt water's corrosive effects. About 2,500 tons of concrete were poured in to the pile caps and for this, a floating concrete batching plant was brought in.

The temperature of the concrete had to be maintained at 36^{0}C and this was a challenge in the hot costal climate. Ice and cooling pipes placed inside the concrete were employed to address this issue. The pile caps were completed after 48 hours of continuous pouring.

UEM Builders constructed the superstructure made up of more than 8,090 concrete box girders joined to form a road deck stretching across the strait.

A 50-acre pre-fabrication factory was set up for this purpose and experts from overseas had to be brought in to ensure that the concrete mix was strong and durable enough to withstand the harsh marine environment.

Among construction challenges include movements of bridge components from land to sea for installation

The process started with casting of the segments, followed by assembly at sea or site. Highly mechanised, purpose made equipment was used at the manufacturing yard.

There was a large amount of steel to be cut and a computerised automated steel-cutting machine was used to cut these into stipulated sizes at a rate that was more than 10 times what could be achieved by traditional cutting methods.

When manufacturing the segments, UEM Builders had to ensure that the shape, elevation geometry, inserts and ducting were compatible because of the s-curve design. In addition to this, each box girder had to be designed for a particular location on the bridge.

Any mistake translates to higher cost and delays, as a segment can only be used 28 days after it is cast, as the concrete has to cure, gain strength and stabilize in terms of shrinkage. The entire history of each segment is documented, so, that future maintenance and repairs have a base design and history to fall back on.

Each concrete box girder was built with up to 6 tons of rebar cut and tied together as a frame, and then carefully covered with up to 100 tonnes of concrete.

A lot of technical consideration and casting control effort had to go into ensuring that steel elements of the structure are protected from the marine environment in the long term, as any interaction of the reinforcing steel with salt water can cause the steel to corrode and the concrete to spall.

The up to 110 ton box girders were loaded onto barges designed to carry 700 ton loads. The seabed alongside the span had to be dredged to keep these barges from getting stuck in the mud as silt along several shallow stretches meant that the channel was only between 2m to 2.5m deep. Silt enough to fill a total 4,800 Olympic size swimming pools was removed during this process and moved to a site 20km away.

A marine traffic control base had to be established to ensure that there were no collisions or incidents between the barges operated by different contractors as well as the already built structures while transporting segmental box girders, equipment and other material. Sea currents and surges had to be monitored closely by the control base.

During construction of the approach span, launching gantries held the box girders up, while high tensile strength steel tendons, post-tensioned to the design requirements, were run through the box girders. The segments joints were waterproofed with high strength adhesive to prevent water ingress into the tendon conduits.

After nine months of bridge span construction and three years after the design and build process starting, the bridge spans originating from the shores of Batu Kawan and Batu Maung met in the middle in April 2013.

Though Malaysia is not located in a tectonically active area, residents of Penang Island and people living along the west Coast of Peninsular Malaysia are not unfamiliar with tsunamis and tremors from the nearby Indian Ocean and Sumatera Island.

With this in mind, the bridge was designed for a seismic load of up to 475-year return period; basically, a statistical projection of the biggest earthquake that can occur in 475 years.

To change the way the bridge would react to an earthquake, the bridge bearings were altered. High damping rubber bearings or seismic bearings, specially designed at the Tun Razak Rubber Research centre in United Kingdom and manufactured locally were incorporated into the pier heads.

The over 1,300 rubber bearings were installed in the bridge. The bearings are made of laminated rubber and metal laminates, and are able to reduce the natural frequency of a structure from 3 to 4 Hertz to 0.4 to 0.5 Hertz in the event of an earthquake. This translates into a resonance resisting behavior of the bridge. This was a pioneering technique.

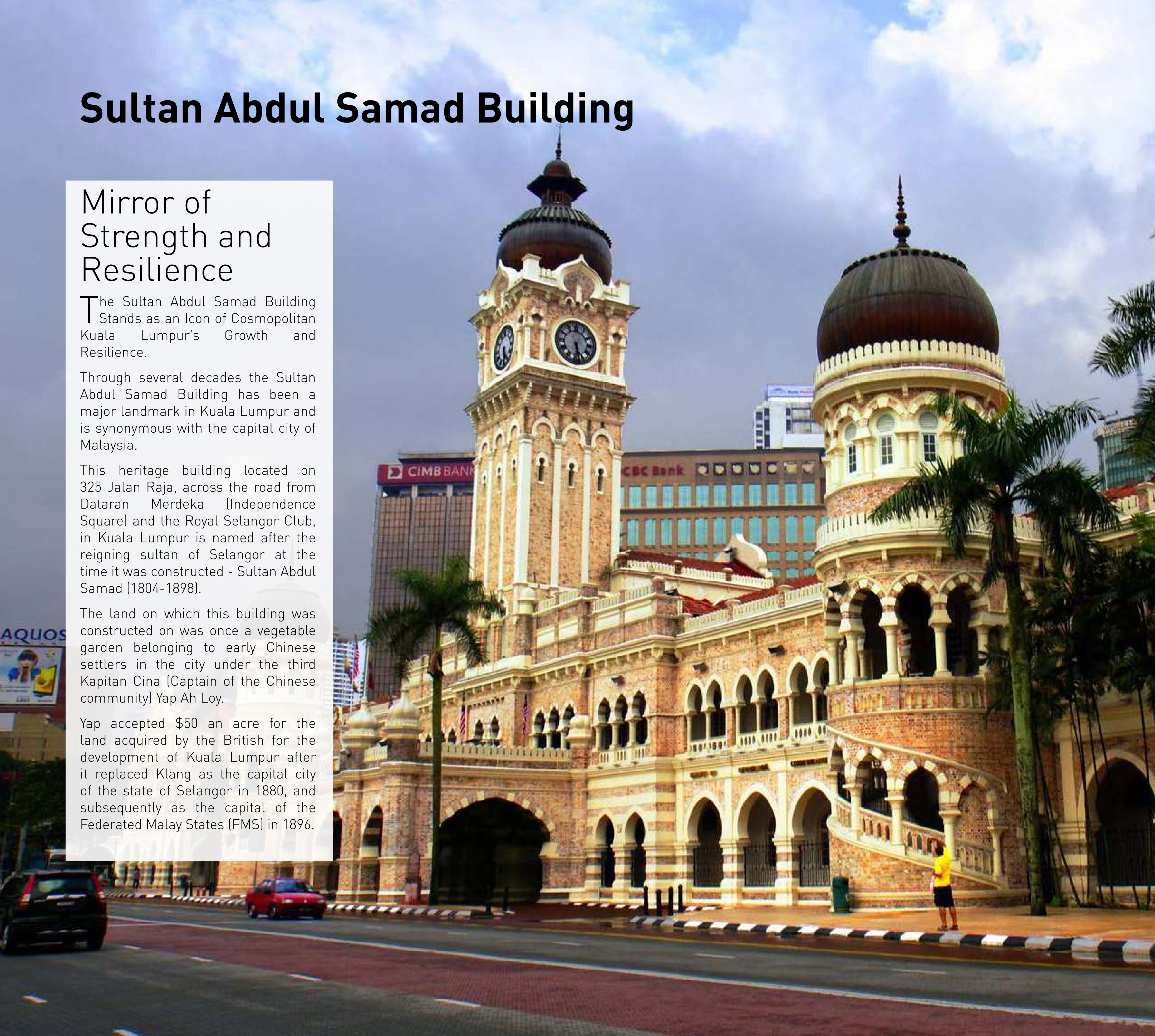
In July 2017, the bridge was closed for installation of wind, tremors, GPS and elevation sensors at the four pylons of the mid-span.

The sensors are part of the element under the Structural Health Monitoring System module of the Integrated Asset Management System (IAMS) developed by JKSB for the maintenance of the bridge.

About four million vehicles have crossed the second Penang Bridge in its first year of operation and traffic has increased steadily since then, and is expected to increase by more than a million vehicles every year.

The bridge has received several awards including the best entry in the Methodology category of the 2016 Global Road Achievement Awards (GRAA) by the International Road Federation (IRF), the 2015 Brunel Medal awarded by the Institution of Civil Engineers (ICE), United Kingdom, and the 2016 China Construction Project Luban Award (Overseas Project) among others ■

Sultan Abdul Samad Building



Mirror of Strength and Resilience

The Sultan Abdul Samad Building Stands as an Icon of Cosmopolitan Kuala Lumpur's Growth and Resilience.

Through several decades the Sultan Abdul Samad Building has been a major landmark in Kuala Lumpur and is synonymous with the capital city of Malaysia.

This heritage building located on 325 Jalan Raja, across the road from Dataran Merdeka (Independence Square) and the Royal Selangor Club, in Kuala Lumpur is named after the reigning sultan of Selangor at the time it was constructed - Sultan Abdul Samad (1804-1898).

The land on which this building was constructed on was once a vegetable garden belonging to early Chinese settlers in the city under the third Kapitan Cina (Captain of the Chinese community) Yap Ah Loy.

Yap accepted $50 an acre for the land acquired by the British for the development of Kuala Lumpur after it replaced Klang as the capital city of the state of Selangor in 1880, and subsequently as the capital of the Federated Malay States (FMS) in 1896.

Sir Frank Swettenham who was appointed as Resident in the state of Selangor in 1882 mooted the development plan to shape Kuala Lumpur during this era.

The Sultan Abdul Samad Building was initially designed to house the colonial state government of Selangor but upon completion it housed the entire FMS administration.

It was known as the "New Government Office" and later as the "Federal Secretariat".

It was named as the "Sultan Abdul Samad Building" in 1974.

The Public Works Department, District Offices, Mines Department, Lands, Audit, and Treasury were housed at the ground floor of this building, while the offices of the Secretariat, a State Council Room, a Sanitary Board Hall, rooms for the Resident and other officials and Chinese Secretariat were located on the first floor.

The Post Office and the Sanitary Board were also located in the same building during that time.

When Selangor transferred its administrative offices to Shah Alam in 1974, the Sultan Abdul Samad building was extensively renovated to house the nation's judiciary.

Between 1978 and March 2007, the building housed the superior courts of the country: the Federal Court of Malaysia, the Court of Appeals and the High Court of Malaya.

The Federal Court and the Court of Appeals moved to the Palace of Justice in Putrajaya in early 2000, while the High Court of Malaya shifted to the Kuala Lumpur Court Complex in 2007.

The building was vacant until the Ministry of Information, Communications and Culture took over in 2007.

The building has since undergone several restoration works including its interior to meet modern office requirements.

This building is an icon of the capital city had been the focal point of many historical events.

It is witness to the declaration of independence, and it was in front of this building that the Union Jack was lowered and replaced with the national flag of Malaysia (now known as the Jalur Gemilang) at the stroke of midnight on August 31, 1957.

On Jan 1, 1982, the clock tower became the venue for another historic event when the time between West Malaysia, Sabah, Sarawak and Singapore were standardized.

National day parades have been held in front of this building for decades as have many other significant national events.

Before this building became the administrative centre, the British colonial administration was located atop a hill on Bluff Road (now Bukit Aman). To accommodate the need for more office space and to make it more accessible to the public, then state engineer of the Selangor Public Works Department (PWD) Charles Edwin Spooner suggested a new building lower down the plain.

Spooner was transferred from Ceylon (Sri Lanka) in 1892 and his idea was to prepare plans for a general office building, with fire-proof rooms for the storage of documents, and a post office.

His idea for a building with a central quadrangle, similar to colonial buildings was turned down as it was too expensive. Following this, A.C. Norman, the Selangor government architect who was involved in restoration of municipal buildings and country houses in the west of England was assigned to design the building. Norman's idea was to showcase a "Classic Renaissance" style with a pillared front.

However, Spooner did not like the design as he felt the adaptation of Arabic-North Indian architectural style was more suited for Malaya which had a predominantly Muslim population.

Spooner thus instructed Arthur Hubback who worked under him and assistant architect R.A.J. Bidwell, to design a building in the Mahometan or Neo-Saracenic style – an eclectic mixture which includes gothic and Italian as well as Islamic elements.

The construction of this design was more expensive at an estimated cost of $152,000.00 Straits Dollar.

Spooner however submitted Bidwell's plan to William Maxwell, the resident of Selangor (1889-1892) and it was approved.

Construction began on Sept 3, 1894. The foundation stone was laid by H.E. Sir Charles B.H. Mitchell, the Governor of the FMS on Oct 6, 1894.

The building was completed within 3 years and officiated by Swettenham who had been promoted to the position on Resident-General of the FMS by then.

Challenges faced during construction of this building were the lack of building materials and supplies. The quantity and quality of building materials required were beyond the capacity of local suppliers to produce.

To resolve this problem, Spooner established a PWD factory equipped with a 40hp engine and a 10 ton flywheel, to drive a sawmill and metal fabricating machine. The factory also made bricks and tiles.

The Sultan Abdul Samad building contains 4 million bricks, 50 tons of fabricated steel and iron, 30,000 cubic feet of timber, 2,500 barrels of cement, 18,000 pikuls (1,088 metric ton) of lime and 4,000 cubic yards of sand.

In terms of design the front façade of the building stretches 137.2 metres (450 feet) along Jalan Raja, making it the largest building of its day. It features a shiny cooper dome, an immense 41.2 metre (135 feet) clock tower which first chimed during Queen Victoria's birthday parade in 1897, central porch, three copper domes topped with a copper chatris and different forms of arches (key hole, ogee, pointed and horseshoe).

Constructed entirely of red bricks, it has a 2 metre wide verandah around both floors which allow for light and air to flow in.

The red bricks are exposed and have white plaster lined arches, and stripes which have become known as blood and bandages style.

Indian patent stone with Islamic geometrical design was used for the flooring.

This building has three towers topped with onion shaped domes with copper coverings.

The tallest is the Central Clock Tower, and the two shorter towers to the left and right of the main tower serve as circulation towers with stairways leading to the upper floors.

This two-storey building occupies a ground area of 4,208.5 square metres (45,300 square feet) with an F-shaped floor plan.

Despite its age this edifice still stands proudly in the heart of the Kuala Lumpur city, and is extensively featured in tourism brochures. It still commands an impressive presence in Kuala Lumpur despite being flanked by modern skyscrapers.

This building has stood the test of time and served the British Colonial administration, the Selangor state administration and the superior courts, in addition to surviving World War 2 and a flash flood that hit Kuala Lumpur in 1971 and a fire that damaged part of the building.

In view of its immense architectural, historical and cultural significance, this structure has been listed as a National Heritage building in 2007 by the National Heritage Department under the National Heritage Act 2005.

The Federal Government in 2009, allocated RM2.37 million (USD 764,516) through the Department of National Heritage for restoration of the Sultan Abdul Samad Building facade.

This building currently houses the Ministry of Information, Communication and Culture, Malaysia ■

This more than 100-year-old building still commands an impressive presence in the heart of KL

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http://mypt3.com/bangunan-sultan-abdul-samad

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Tabung Haji Tower

The Tabung Haji building has a distinctive design that gives a subtle and humble hint of its role of helping so many Muslims in Malaysia achieve their dream of embarking on a pilgrimage to Mecca.

The design of the Tabung Haji building in Kuala Lumpur by its project consultant Hijjas Kasturi expresses the qualities of the organisation it houses; a corporate body owned and operated for Malaysian pilgrims.

The architecture of the building visually reflects the journey of a Muslim haj pilgrim - hard work, the saving and the planning over a lifetime that culminates in a pilgrimage which a fulfilment of one of the five principles in Islam, and one that unites all Muslims regardless of which sects they belong to.

The building owner Tabung Haji Incorporated appointed Hijjas Kasturi to carry out feasibility studies and propose the building design in accordance to the project brief, which was to ensure that the stability of Tabung Haji and Islamic concepts were reflected in the structure.

The structure in Kuala Lumpur city centre also accommodates tenants. Therefore careful attention had to given to segregating the two functions, and to ensure flexibility for future growth at the same time.

The segregation was also necessary to ensure that the practices of staff, users, visitors and pilgrims, to the owner's part of the building which are mainly Muslim are taken into account.

The unique design of the structure is tailored to inspire the faithful and be reflective of their faith.

The basis for the design takes into account:

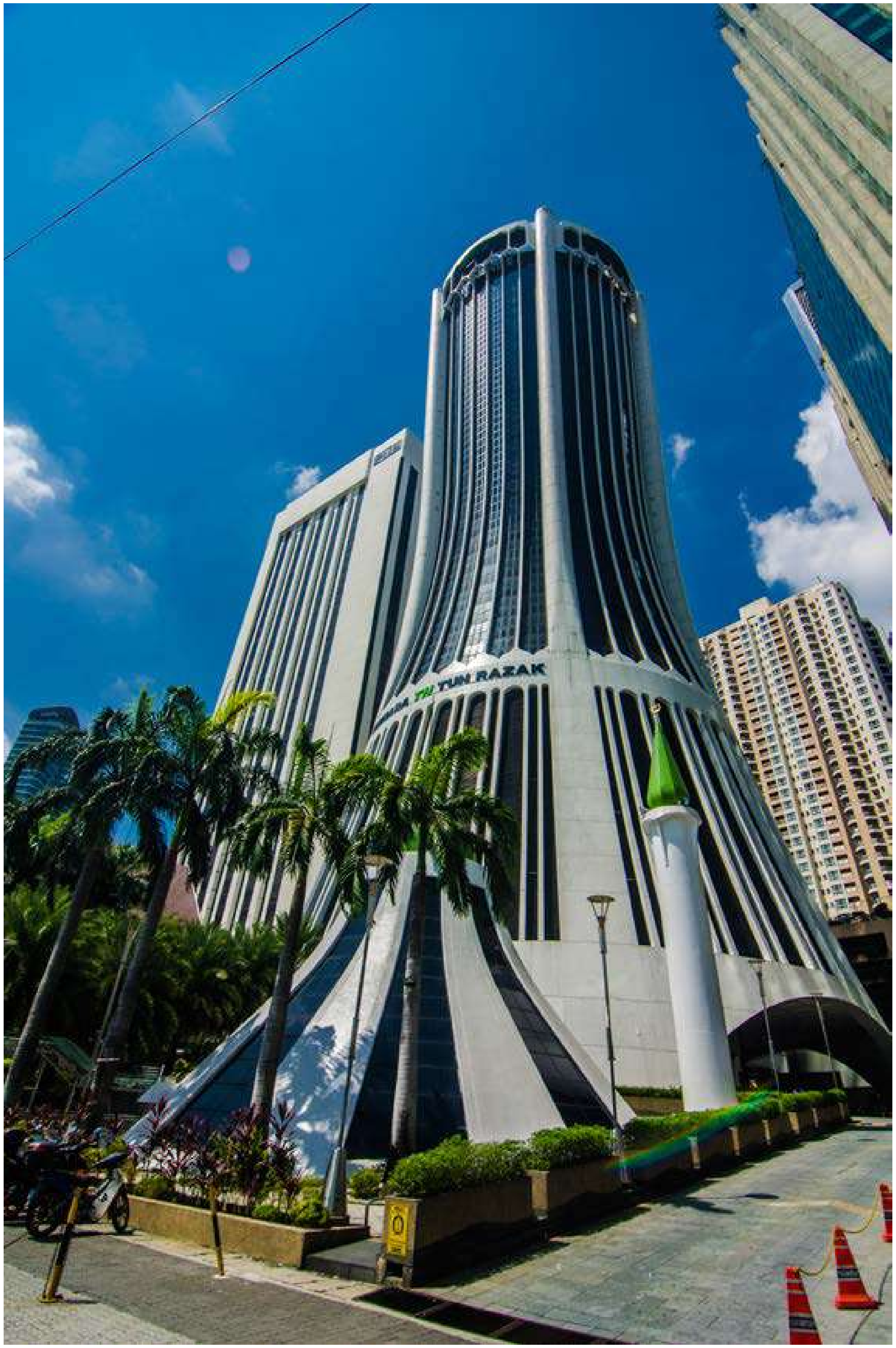
- Simplicity, which is the simple declaration of belief for Muslims.
- Discipline, as required in the performance of daily prayer and annual fasting.
- Unity, of an architectural form that reflects oneness with humanity by crossing the barriers of secular division to build fellowship and brotherhood that is essential in Islam.

The flare at the base of the tower has a functional purpose - accommodating traffic flow and greater space demand. The flare to the top balances the form of the structure, while the circular service core enhances the benefit of the building from both an artistic and economic point of view.

Islamic buildings are usually endowed with features representing the five principles of the religion which are faith, prayer, fasting, charity and pilgrimage to Mecca.

The Tabung Haji building likewise is supported by five huge columns which fulfil its structural requirements, but are never simultaneously visible from any vantage point. This espouses the concept of the faith, that the five principles of the religion which are the spiritual structures of a Muslim's life are not something that should be flaunted.

About 70% of the external wall is built with tempered glass to allow natural light and saves energy



The five columns also accommodate a peripheral package air conditioning system that offers maximum flexibility of usage.

Each unit serves one fifth of its floor area and can be individually operated, thus minimising maintenance costs.

The thin horizontal bands joining the five columns signify a society that is supported by the five principles of Islam. These projections over the windows also serves to reduce glare and heat from the sun, as a fire protection ledge, to reduce the flow of rainwater to the surface of the building and as cleaning platforms for the outer windows.

Two clusters of lift serve the building, while limited ancillary facilities cater for pilgrim's needs.

An underground auditorium and lecture halls are connected to the mosque, which is also underground, but identifiable from above by a simple non-dominant dome.

The design of Tabung Haji building is radical in a sense that it does not follow the traditional pattern of Islamic architecture either in Malaysia or other Muslim countries.

However, those familiar with the evolution of architectural styles will be able to spot the distinctively Islamic nature that is fused with the economic and functional requirements of a modern multi storey commercial building.

The structure houses 25 stories of office space with varying floor space of between 5,945 sq feet to 9,795 sq feet. Each floor commands a 360 degree view of the city and is served by five package airconditioning split units that can easily be controlled and compartmentalised.

The structure of the Tabung Haji building is famed for its use of pillars to support the 39-storey circular structure of pre-stressed reinforced concrete, brick, steel plate and tempered glass.

The internal design and structure incorporates marble, cement render, asbestos, metal and tempered glass.

The design process took a year - 1981 to 1982 followed by construction and completion in 1984. New materials and technologies incorporated into the building at that time included a Building Automation System (BAS) control centre and lift supervisory panel among others.

Green building concept and designs were rare at the time Tabung Haji was constructed but with 70% of the external wall built with tempered glass which allows natural daylight in, the building would require a lot less energy for lighting.

The main challenges faced involved coordinating all trade/sub-contractors, architects, M&E and C&S teams to ensure no overlap of duties and clash of services during construction.

This was overcome with good teamwork, effective site coordination and fast response by all team members i.e architects, structural engineers, M&E engineers and main contractors.

A project management team with the right experience and attitude was crucial in ensuring that the project was completed in time and in accordance to specifications ■

Universiti Teknologi Petronas (UTP)

In synergy with nature

The Universiti Teknologi PETRONAS is a building that aspires to inspire its students, and the future generation with thought provoking designs and solutions that create a synergy between nature, design and technology.

Universiti Teknologi PETRONAS (UTP) is located within the beautiful setting and dramatic landscape of Bandar Seri Iskandar, 300km north of Kuala Lumpur.

Institut Teknologi Petronas Sdn Bhd in its project brief asked for a state-of-the art university for Petronas, offering engineering and technology programmes at undergraduate and postgraduate levels with a capacity to accommodate over 6,000 students.

The facilities would comprise of faculties for Information Technology, Information Systems, Chemical Engineering, Civil Engineering, Mechanical Engineering, Science and Mathematics, Electrical and Electronic Engineering, and Common Engineering.

In an effort to become the leading engineering institution of higher learning in Malaysia and the far east region, the campus includes research and teaching laboratories consisting of Advanced Metallurgy, Polymer Technology, Petroleum Production Engineering, Offshore Structures, Fluid Dynamics, Pilot Plant / Unit Operation, High Pressure Chemical Reaction, Petrochemical, Digital Signal Processing, Advanced Structural Engineering, Hydraulics/Hydrology/ Water Resources, Geotechnical Engineering and Highway and Transportation Engineering.

Institut Teknologi Petronas Sdn Bhd took the initiative to engage world-renowned architects Foster & Partners from the United Kingdom as the overall designer which collaborated with GDP Architects Sdn Bhd to plan and design the university.

KLCC Projeks Sdn Bhd was appointed as project and development managers and Shah, P.K. & Associates Sdn Bhd as the landscape architect.

The team also included C&S Engineers Meinhardt (Malaysia) Sdn Bhd (Chancellor Building) and Ranhill Bersekutu Sdn Bhd (Academic Buildings), M&E engineers Majutek Perunding (Chancellor Building & Academic Buildings) and Quantity Surveyors Konsortium KPK JUBM Sdn Bhd.

Construction spanned over a period of three years and was completed in 2004.

The UTP campus is an iconic form in its own right and one that does not dominate its natural setting.

The site is located in a valley with five saddles from the surrounding hills.

The masterplan for the campus took the form of a star configuration, the geometry of which was largely dictated by the contours of the surrounding terrain.

The resultant star configuration lends itself easily to the creation of a central landscape park, which blends the university seamlessly into its natural forest setting.

The Chancellor Complex greets visitors to the university via a well-proportioned plaza - a 'drum-like' building that acts as a gateway into the campus.

This structure of steel and glass gives a sense of space to the area, and reveals the functional usage of the building as well as the intricate but subtle traditional 'songket' design of the cladding.

The 4-storey academic blocks were designed, based on a modular dimension to accommodate the needs of various faculties.

With the modular design, the buildings enable the accommodation of learning spaces and laboratories of various sizes.

The 'pockets' which house businesses, academic and social amenities such as banking facilities, cafeteria, shops, a post-office, a clinic and prayer halls, are strategically located at the confluence of the academic blocks.

The buildings are painted with bright colours to contribute to a lively campus atmosphere.

UTP was built with students, staff, and the natural environment in mind, with special care taken particularly in the spaces where people and the natural landscape would intersect.

The academic complex is divided into several blocks laid out in a radial manner, which allows for maximum cross ventilation and natural lighting in-between the blocks.

Within the blocks, laboratories and teaching spaces are accessible either by a central corridor or side corridors, and these again promotes cross-ventilation within the blocks.

A prominent feature of this complex is the main canopy roof which integrates the built form, forming a visually unifying element for the complex.

The tall columns of the canopy emulate tall trunks of the surrounding forest trees. The canopy which sails over the main circulation deck linking the front of each block, has enough height to allow for wind and view, but at the same time provide ample shade against the harsh sun and driving rain. The canopy tames the climate, creating a cooler microclimate to encourage users to spend time outside amidst the extraordinarily lush landscape.

The introduction of water elements was incorporated to create an oasis of tranquillity in the midst of academic activities.

The deck itself forms the primary pedestrian link throughout the complex with seating areas affording informal opportunities for students to meet and discuss ideas.

Wherever possible, the buildings make use of cantilevered passive shading devices attached to the roof edges to keep the buildings cool.

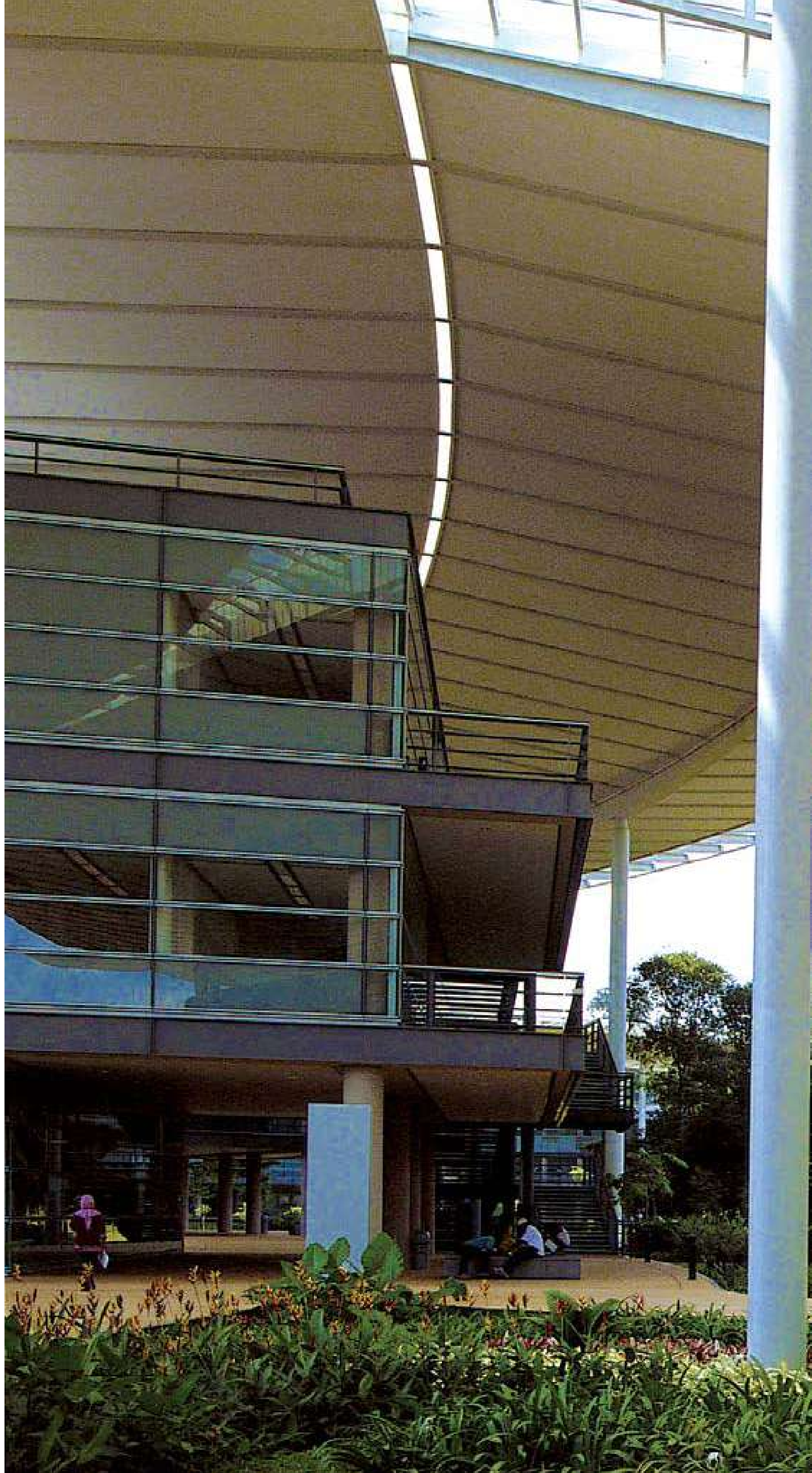
A combination of clear and opaque glass panels cladding the buildings assist in reduction of solar heat gain.

The modular design of the academic blocks optimises structural design, provision of services and flexibility in creation of teaching spaces within.

The first task for the architects was to establish the brief for the campus.

This was done with guidance from a consultancy from San Diego, Research Facilities Design, which specializes exclusively in the programming and design of laboratory facilities for universities.

There were extensive workshops and dialogue between the design team and academicians in this process of finalising the brief.



Secondly, much effort was put into analysing the project site, in order to preserve as much of the existing forest eco-system and terrain.

For GDP Architects this was one of their earliest collaborative projects with foreign expertise.

It is through such collaborative exercises over the years that GDP has been able to develop long term partnerships with various world-renowned architects, that continue till today.

One important focus of this project was that it was to be a world-class institution, with inspiring, timeless architecture and built-form.

The aim was for the design to exude natural harmony with its surroundings, thus central to the design was care for the environment.

As such, the masterplan of the campus was generated from the contours of the landscape and wherever possible, natural vegetation was left undisturbed.

In terms of materials used and incorporated into the design the focus was on blending the building in with its natural surroundings. The main deck is finished with an earth-coloured aggregate, emulating the soil on which the complex sits on.

The grey and reflective nature of the glass cladding reflects and blends the building with its lush landscape surroundings.

While the extensive use of perforated pavers with turfing, along the roads attempts to bring landscape into the development.

Customised prefabricated panels which were used at the Chancellor Complex which houses the Main Hall, the Resource Centre and the administrative offices, was aimed at injecting local charm, reminiscent of the traditional songket fabric.

Even though the building was not accorded with a green rating, design provisions were made with sustainability in mind, through the proper selection of built-form materials, and monitoring and evaluation systems.

This project came with its fair share of challenges. In the early part of the construction process, local contractors struggled due to limited experience in putting up an extensively detailed building.

However, a strong collaborative spirit and a relentless pursuit of continuous coordination with the contractors and subcontractors by way of technical meetings, extensive use of shop drawings, prototypes, benchmarking of building components for quality acceptance, helped overcome the challenges.

Strong coordination with all parties involved and clear leadership were essential in the construction of this UTP campus.

These were key elements of the project's success in delivering the design intentions that were planned and promised.

To ensure that the project was delivered on time and within budget constant monitoring of delays and implementation of recovery measures were done. Cost check was carried out at milestone stages of the design, and variations were tracked meticulously during construction.

This building won the Aga Khan Award For Architecture (The Tenth Award Cycle, 2005-2007) and the PAM Awards 2006: Winner (Public and Civic Buildings) ■

University College of Technology Sarawak

Green University in Sibu

The UCTS pays tribute to Sibu and promotes the conservation of natural resources upon which this town was built upon.

The University College of Technology Sarawak (UCTS) is UCTS is the first university in Malaysia and the world to achieve a Platinum Rating for the Green Building Index (GBI) award. It is also among the few universities in Malaysia to have its very own Technology Park. The building design reflects the university's endeavour to become a high-tech, world class institution that offers students a fully integrated, comfortable, user-friendly and conducive learning environment.

To reflect the progressive objectives of the university, it is designed to give the illusion that it is in motion.

The project brief for the UCTS campus was presented in mid-April 2012 and the design team took about three and a half months to complete the blueprint.

Prime Minister Datuk Seri Najib Abdul Razak officiated the ground breaking ceremony for the campus that covers 44.08 ha of land on Sept 16, 2012.

The university commenced operations on April 1, 2013 after the first phase was completed.

UCTS involved in the design process and constant briefings and presentations were held throughout the entire duration of the project to iron out the design and costing.

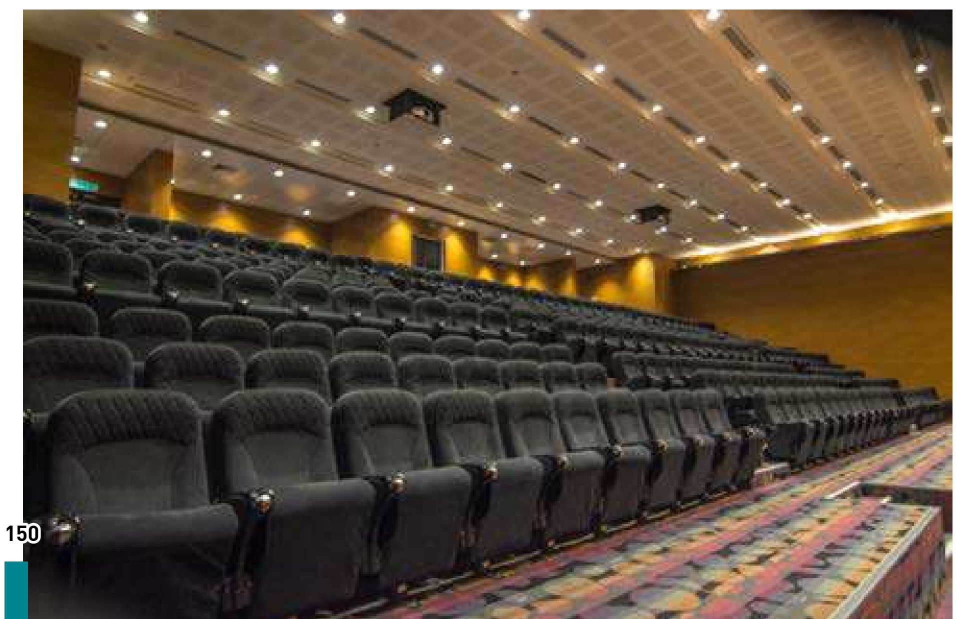
The university is located in Sibu, which is rich in history and one of the main stops along the Rejang river.

This historical significance is incorporated into the design of the UCTS campus.

Inspired by the river along which this town flourished, the design recreates a sense of arrival in Sibu via the waterway.

In the old days, before the emergence of road and air transportation, the river was the main mode of transport and livelihood for the people of Sibu, and the university's design aims to remind its students and future generations of this.

This is replicated by the large body of water in front of the UCTS campus which features a silhouette of the Rejang river and its tributaries.



Sibu is also known as 'Timber Town' and thrived because of the timber trade.

The town is surrounded by lush rainforest that is home to many species of flora and fauna.

Toreflect this and the town's timber trade, the design team adopted a 'forest canopy' concept in parts of the campus where students gather for social activities.

In these designated areas, trees like the SelanganBatu, Belian, Raminand others that brought much wealth and development to Sibu are planted to provide a natural surrounding for students to draw inspiration from.

It also serves to remind the community in Sibu of the resources in the surrounding forests that sparked the growth of this town.

The next phase of development forSibu will be technologically orientated.

The UCTS campus reflects this with a futuristic look that employs the latest technologically advanced building materials.

Selection of building materials werecrucial to meet the stringent requirements of the GBI.

Green products with low Volatile Organic Compound (VOC) content, finishes with no added urea formaldehyde, recycled content materials like aluminium and glass, eleganstone finishes and metal roofing with high Solar Reflectance Index (SRI) were therefore selected.

Materials and technologies incorporated in this project are available in the market anytime it is needed.

This was to ensure thatmaintenance of the UCTS building in the future would be hassle free.

The moveable photovoltaic panel would probably be the least common materialused.

It is featured as a 'high-tech' show piece at the entrance of the university.

During the planning stage, UCTS's focus was to be the first university globally and locally to receive a GBI certification. The key green building / sustainable architecture design elements towards this are:

- Integrated photovoltaic panel whichis able to generate 70kW of electricity per day;
- Advanced building envelope to minimize heat gain including special low-emissive glass and insulated roofs;
- Variable speed drive chilled with VAV System for the air-conditioning system;
- Rainwater harvesting and water recycling system that will reduce potable water consumption;
- Use of energy saving lifts that are registered with GBI;
- Use of low Volatile Organic Compound (VOC) building products and finishes with no added urea formaldehyde;
- Non-chemical Water Treatment System for condenser or chilled water circuit;
- Use of Dali Dimming System to act as auto sensor controlled lighting in conjunction with daylight strategy for all perimeter zones and daylight areas;
- Carbon Dioxide (CO2) Monitoring and Control System with at least one CO2 sensor at all main return points on each floor to facilitate continuous monitoring and adjustment of outside air ventilation rates to each floor, and ensure independent control of ventilation rates to maintain CO2 levels at 1,000 ≤ ppm;
- 60-degree slanting curtain wall to eliminate glare from direct sun penetration and diffuse sky radiation to the maximum;
- Green carpark to encourage students to use low emitting and fuel efficient vehicles;
- 5% of total parking spaces allotted as preferred parking for carpools or vanpools;
- White roofing that apply the highest Solar Reflectance Index (SRI) value of 79 and all paving material apply Solar Reflectance Index (SRI) at of least 29;
- All wastewater and greywater will be treated at the Sewage Treatment Plant (STP) and will be recycled for irrigation and landscaping;
- Sanitary fittings are water efficient and aimed at reducing annual potable water consumption by ≥ 50%; and
- All sub-meters installed, including that to monitor and manage major water usage for cooling towers, irrigation, kitchens and tenancy use are linked to early warning systems to facilitate early detection of any leakage.

It was important for UCTS to achieve the GBI for the growth and development of the students and the community it serves, as habits and methods employed by the community has a large impact on the natural environment.

In a bid to instil the concept of environmental protection and sustainability amongst its students and community, the university pushed for manufacturing, design and construction that reduces consumption of natural resources.

Towards this, the biggest challenge faced by the team that designed and built the UCTS was the short deadline given.

The second challenge was ensuring it fulfilled all the criteria required for GBI's 'platinum' status within this timeframe.

To overcome the first challenge, the university building design was broken into smaller modules of buildings for each of the departments/faculties.

This helped speed up construction, and enabled several building complexes to be constructed simultaneously.

The workforce was also increased to meet the deadline. There were over 700 workers working on the project at any one time.

To overcome the second challenge, the design team was careful in its consideration of building design, detailing andspecification of materials.

The team was also meticulous in formulating designswhich conserve energy, and which integrate the latest available efficient mechanical and electrical equipment.

There were relatively few projects in Malaysia which have achieved the GBI 'platinum' status to be used as a benchmark and the UCTS team visited some of these, including the Malaysian Energy Commission headquarters in Putrajaya.

The team also researched similar platinum status GBI buildings in publications, and attended seminars and conferences in order to gain knowledge and ideas for UCTS's design.

The key drive for the success of this project was the team work.

The team worked around the clock to achieve the challenges, and their commitment helped overcome obstacles encountered during the duration of this fast track project.

There was constant design scrutiny, and close collaboration and coordination between consultants of this project to ensure drawings issued were accurate and complete.

Fortnightly site meetings were held to ensure close monitoring of work progress, and that the cost remainedwithin the budget.

This detailed briefing, regular routine inspection and close monitoring of work by the contractor and subcontractors at every stage of work was necessary to ensure that the building was completed in time. Constant communication was crucial towards this.

All stakeholders benefited from the process and knowledge garnered from this project which infused a greater understanding of green building design and construction ■

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