

A study on the petronas towers construction essay



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Supertall buildings are a relatively recent addition to the history of the cities around the world. Technology of the nineteenth century made their development possible. Steel, concrete and masonry materials have existed for a long time in the history of civilization but not in such a configuration. Masonry is the oldest material. Concrete in its present form is the youngest of these three basic structural materials of construction. Concrete, unlike any other structural building material, allows the architects and engineers to choose not only its mode of production, but its material properties as well. Although steel will continue to be the structural material of choice for many tall buildings for its strength and ductility, we may expect to see more and more concrete and composite high-rise structures shaping the skylines of major cities of the world in the forthcoming years.

As a result, the field of concrete tall building construction is rapidly changing and its limits are constantly being tested and stretched. The introduction of composite construction to tall tubular buildings has paved the way for supertall composite buildings like the PETRONAS Towers.

1. INTRODUCTION

Much of the technological change in concrete construction was in the first half of the 20th century. Advances in formwork, mixing of concrete, techniques for pumping, and types of admixtures to improve quality have all contributed to the ease of working with concrete in high-rise construction. There were main four periods in the development of skyscraper which began around 1808 and ended in 1960s where structures were usually vertical and dominant. During 1970s the international modernism in construction started

to rise and this introduced a renewed interest in silhouettes and symbolic potential.

The most efficient construction coordination plan for a tall building is one that allows formwork to be reused multiple times. Traditionally, formwork was made of wood but as technology has advanced, the forms have become a combination of wood, steel, aluminum, fiberglass and plastic, to name only a few materials. Each set may be self-supporting with trusses attached to the exterior or may need additional shoring to support it in appropriate locations. New additions to the family of forms include flying-forms, slip forms, and jump forms. The PETRONAS towers are a good example of this latest period.

The techniques improved continually till now when pumping of concrete is considered even for small jobs. In recent years, concrete pumping has reached new heights. The builders for the Jin Mao Building in Shanghai, China, boast of pumping high strength concrete as high as 1200 ft (366 m). For such great heights, a high-pressure unit is needed. Great thought must be given to the properties of concrete and how it will react when pressure is applied in a pipe. All these factors demanded innovations in concrete technology.

2. THE SKYSCRAPERS

Already a well-argued case between Architects and Engineers is to build a environment with minimal impact on natural environment and to integrate the built environment with ecological systems of the locality. This proposition of the skyscraper as an ecologically- responsive building might well appear to be a conundrum for some. Afterall; Skyscraper is the city's most intensive

building-type of enormous size. The council on tall Buildings and Urban habitat in USA defines the skyscraper as a tall building whose built form that by virtue of its height requires its own special engineering systems.

Figure

3. PETRONAS

PETRONAS was incorporated on 17 August 1974 as the national oil company of Malaysia, vested with the entire ownership and control of the petroleum resources in the country. It has since grown from merely being the manager and regulator of Malaysia's upstream sector into a fully integrated oil and gas corporation, ranked among the FORTUNE Global 500® largest corporations in the world. The national oil company along with investors and federal government of Malaysia decided to construct the PETRONAS Towers which will be a major headquarter for the company along with other offices mentioned above. PETRONAS in the best possible way tried to balance and integrate economic, environmental and social considerations into their business decisions. These considerations include, among others, strong HSE management and performance, continuous development has made a holistic contribution to the society. Below is the graph that shows the financial outlook of the company

Figure

4. HISTORY

Designed by Argentine architects César Pelli and Djay Cerico under the consultancy of Julius Gold, the PETRONAS Towers were completed in 1998 after a seven year build and became the tallest buildings in the world on the

date of completion. They were built on the site of Kuala Lumpur's race track. Because of the depth of the bedrock; the buildings were built on the world's deepest foundations. The 120-meter foundations were built within 12 months by Bachy Soletanche and required massive amounts of concrete. Its engineering designs on structural framework were contributed by Haitian engineer Domo Obiasse and colleagues Aris Battista and Princess D Battista.

PETRONAS took the challenge to develop the PETRONAS Twin Towers in 1991. The project is an integral part of the Kuala Lumpur City Centre (KLCC), a carefully planned development to provide the capital city with an efficient and modern centre for urban activity, trade and commerce encircling a vast, open green lung. It brought together the world's leading practitioners of engineering, building technology and construction. Construction planning began in January 1992. By March 1993, the excavators were hard at work digging down to 30 meters below the surface of the site.

The extent of excavation required over 500 truck-loads of earth to be moved every night.

The next stage was the single largest and longest concrete pour in Malaysian history: 13, 200 cubic meters of concrete was continuously poured through a period of 54 hours for each tower. This record-breaking slab, together with 104 piles forms the foundation for each of the towers.

From this floor rose a 21-metre high retaining wall, with a perimeter length of over 1 kilometer. This concrete shell and the basement area it enclosed required two years of up to 40 workers on site all day and night. The final product is the basement car park offering a total of 5, 400 parking bays on

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five levels beneath the podium wrapping the towers. As an added consideration, two different contractors were chosen for each tower to allow cross-monitoring of construction values and techniques - with one coming to the aid of the other should problems arise. The construction of the superstructure commenced in April 1994, after rigorous tests and simulations of wind and structural loads on the design.

5. PETRONAS TOWERS

The PETRONAS towers are part of a massive real estate development on a 100 acre site in Kuala Lumpur which eventually after completion now has office buildings, a retail centre, hotels, residential buildings and substantial public parks, gardens and lakes. The twin PETRONAS towers are linked by a sky bridge at mid height. It consists of 216, 901 square meter of total floor space, 88 levels rising to a height of 450m above street level.

This was the first project in Malaysia where high strength concrete was specified. To achieve completion of the structural frame in approximately 28 months every floor needed to be constructed in approximately 4.3 days putting great pressure on the contractor to achieve rapid, delay free construction.

The main structural system for the super structure and foundation were selected after a rigorous study and evaluation by the design and project management team. The structural approach in the tower frame combines the most favorable aspects of concrete and steel construction.

Figure

6. PRECONSTRUCTION CONSULTANCY

Due to the nature of the project, being the first super tall structure of its kind in Malaysia and very limited experience with the use of high strength concrete, the contractors were required to demonstrate that the requirements of the project could be successfully achieved prior to actual construction of structural elements. The contractor Samsung-Kukdong-Jasatera joint ventures were to do it. The major engineering and structural design teams were a collection of eminent international companies and consultants including such notables as César Pelli & Associates, Hazama Corporation, Adamson Associates Architects, Solétanche Bachy, RSP Architects Planners & Engineers, Samsung Engineering & Construction, Mitsubishi Heavy Industries Ltd., Syarikat Jasatera Sdn Bhd., and several dozen other major international firms. Legions of support engineers and designers in an array of specific disciplines contributed over the course of the years.

7. SITE AND DESIGN

The site for PETRONAS Towers is the Golden Triangle. Around it radiates the city of Kuala Lumpur, Malaysia's capital. The jewel of this 100-acre site are the towers. Working within mixed-used development plan by U. S firm of Klages, Carter, Vail and Partners. The design drawings show a complex of buildings growing from an intimate relationship with the site, generating from its core. The concert halls provide an important gathering space.

Figure

Map showing the Kuala Lumpur City Centre

PETRONAS Towers I & II

Concert Hall

Suria KLCC Retail Complex

Office Tower (Menara Maxis, Menara Esso)

Mandarin Oriental Hotel

Future Buildings

8. FLOOR PLAN

PETRONAS towers floor plan when viewed appears as two overlapping squares to create an eight pointed star which is further refined with half-circles between star points. The spirit of geometry is Islamic which dominant Malaysian culture is. Other eastern forms are woven into tower's form. The towers are placed on a central axis.

Figure

9. DESIGN METHODOLOGY

The design for the PETRONAS Towers was not a written document or a set of drawings for the contractors to follow when building the structure. It was instead an evolving process that took place over the course of many years. This enormous amount of communication and the design considerations that were discussed produced a final result that differs considerably from the plan that won the first Kuala Lumpur City Center design competition held in 1991.

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The number of designers, engineers, and building contractor management personnel that took part in the design process is about the same as the number of workers that actually built the towers. About 7, 000 construction workers took place in the actual building of the towers, as there was a great concern for the congestion that would occur in the busy Kuala Lumpur city center. 7, 000 design workers talking constantly among themselves for five or six years designed the building. It was certainly an impressive conversation. Although much of this talk took place directly between individuals, this project probably would not have been possible before the development of the Internet or sophisticated project and communication management software.

Every phase of the process, from the drawings and engineering research down to the daily work orders was accomplished with cutting edge software that was in many cases as technologically innovative as other parts of the project.

The high quality of the PETRONAS Towers is the result of the quality of the design team. Although César Pelli was the titular designer and he served as the lead visionary, the design contributors included Prime Minister Dr. Mahathir, businessman T. Ananda Krishnan, senior managers of the PETRONAS company, the Kuala Lumpur City Center planning manager Arlida Ariff, and many high ranking national and local politicians..

The design process itself was as much a marvel as are the physical towers visible today. When construction began the design did not call for the tallest buildings in the world and the entire foundation was moved after excavations

had already begun. The parking garage was located up inside the towers in César Pelli's first drawings and the powerful Skybridge was absent from the original 1990 Klages Carter Vail & Partners plans for the Kuala Lumpur City Center development that first called for two towers. These and many more features of the project changed as the design for the project evolved continuously over the life of the project and the final result is a testament to the efficiency of the whole multi-year design process.

10. CONSTRUCTION

One of the first challenges that were faced during the towers constructions was anchoring the towers to the ground. The bedrock beneath the site was very irregular and thorn-ton-tomasetti, the structural engineers suggested to relocate the towers about 200 ft to be able to bear on soil.

The towers were framed with concrete walls and columns. In Malaysia the contractors were comfortable working with steel and concrete, concrete and steel actually helps in reducing the wind sways and minimize vibrations.

Construction of towers was fast paced, because it was a decision to have two contractors one for each tower that created a competitive environment and work commenced at a faster phase. One of the most dramatic feats was placement of the two story sky bridge, which was built on the ground and hoisted to its location joining the 41st floor and 42nd floors. The construction of the PETRONAS Towers was a model of cooperation and efficiency and in some respects even more spectacular than the final result.

Figure

Figure

After a year of planning, the construction phase began in March 1993 with the excavation work for the foundation. The originally selected location was moved 60 meters due to the configuration of the bedrock exposed during the excavations. The excavation for the foundation went 30 meters below the soil surface, with work proceeding only after sunset and more than five hundred dump trucks full of soil being removed from the site each night.

For each of the two towers, more than one hundred foundation piles were poured next. Once the forms were in place, the slabs for the foundation of the two towers were poured in two continuous pours lasting about two and a half days each and using over 13, 000 cubic feet of concrete for each of the two slabs. On top of these slabs a perimeter wall over a kilometer in total length and 21 meters tall was created to form the shell that would become the five-level underground car park.

The contract to construct the two towers was given to two different contracting companies and their friendly competition resulted in both remarkable speed and valuable cooperation as each team shared with the other information gained during the building process.

Tower One, which houses the PETRONAS headquarters, was built by a group led by the Japanese Hazama Corporation along with J. A Jones Construction of Charlotte North Carolina, and the Mitsubishi Corporation, MMC Engineering, and Ho Hop Construction of Japan.

Tower Two was constructed by the SKJ Consortium, composed of Samsung Engineering & Construction and Kuku Dong Engineering & Construction from Korea, Dragages and Bachy-Soletanche from Singapore and Syarikat Jasatera and First Nationwide Engineering Sdn Bhd from Malaysia.

Work on the tower structures started in April 1994 was completed by June 1996, with the first tenants moving into the buildings in 1998. The Malaysian Prime Minister Mahathir bin Mohammad presided over the opening ceremonies for the towers on Aug. 31, 1999, which coincided with the celebration of Malaysia's Hari Kebangsaan holiday that marks the unification of the country and the establishment of the Malaya Federation in 1957.

Although many foreign firms participated in the construction process, a great deal of the work was done by local Malaysian companies. It is estimated that sixty percent of the materials used in the construction were obtained locally. All of the concrete and construction timber was Malaysian in origin as were many of the interior finishing materials including marble, ceramic tiles, and drywall materials. Many of the more complex features such as escalators, electrical fixtures and components and furniture were also supplied by Malaysian firms.

11. DETAILED STRUCTURAL ANALYSIS

The functional structures of the PETRONAS Towers were designed by the structural engineers Thornton-Tomasetti, with headquarters in New York, and Ranill-Berskutu of Malaysia. The core structure of each of the towers is composed of a ring of sixteen cylindrical columns of high strength reinforced concrete. The columns vary in size from 2.4 meters in diameter at the lower

areas to 1.2 meters in diameter at the top, and are placed at the outside corners and additional arcs of the eight pointed star shape that gives the buildings their classic Islamic shape. In a staging of six increments, the columns slope slightly inward as they rise, resulting in the tapered form of the final buildings. The columns are linked with a series of concrete core walls and ring beams and the architect César Pelli has described these movement-resistant and damper-free structures as a pair of “soft tubes”. There are actually two concentric pressurized cores in the structures, and the two cores unite at the 38th floor of each tower.

A significant choice of building materials was made early in the project, and it was decided to use reinforced concrete instead of the structural steel that is more common in other skyscrapers. This choice was made not only because local Malaysian contractors were more experienced building with concrete than with steel, but also because the cost of importing all the steel would have been prohibitive, whereas the concrete could be obtained locally. The final towers weigh more than twice what they would have had steel been used, but it was additionally felt that the use of concrete would more effectively dampen sway in windy conditions and reduce vibrations within the towers.

The structural plan liberates additional floor space inside the towers by locating the mechanical services for the towers in two “bustles” that are 43 story tall buildings located immediately adjacent to the towers. After completion, the exteriors of the two concrete “soft tubes” were clad in stainless steel and glass with a design that originated in the classic geometric patterns of ancient Islamic art. The foundations for the structures

are huge concrete cores and are considered the deepest building foundations in the world.

The two 73-meter tall pinnacle structures of the towers were, like the towers, constructed by two different contractors. One of the pinnacles was fabricated in Japan and the other in Korea. Built of structural steel and then disassembled and shipped to Kuala Lumpur, the pinnacles were reassembled and mounted atop the towers in yet another delicate operation that required several months of practice before the final installation. The two pinnacles are clad in brushed stainless steel.

Each tower used 11, 000 tons of reinforcement steel, 2, 825, 120 cubic feet of high-strength concrete, almost 7, 500 tons of structural steel beams and 830, 000 square feet of glass windows.

Figure

12. SKYBRIDGE

The towers feature a skybridge between the two towers on 41st and 42nd floors, which is the highest 2-story bridge in the world. It is not directly bolted to the main structure, but is instead designed to slide in and out of the towers to prevent it from breaking during high winds. The bridge is 170 m (558 ft) above the ground and 58 m (190 ft) long, weighing 750 tons. The same floor is also known as the podium, since visitors desiring to go to higher levels have to change elevators here.

Figure

13. THE LIFT SYSTEM

The main bank Otis Lifts is located in the centre of each tower. All main lifts are double decker with the lower deck of the lift taking passengers to odd numbered floors and upper deck to even numbered floors.

From the ground floor, there are three groups of lifts.

The “ short haul” group of 6 lifts takes passengers to floors between level 2/3 and level 16/17. The “ mid haul” groups of 6 lifts take passengers to floors between level 18/19 and level 37/38. There is also a set of shuttle lifts that take passengers directly to levels 41/42. To get to levels above 41/42, passengers must take the shuttle lifts, and then change to lifts to the upper floors. These connecting lifts are directly above the lifts that serve levels 2 to 38. The pattern now repeats with the upper levels, one set serving levels 43/44 to 57/58 and one set serving levels 59/60 to levels 73/74.

Apart from this main bank of lifts, there are a series of lifts to take people between the groups. Unlike the main lifts, these are not the double-decker type. Two lifts are provided to take people from levels 37/38 to levels 41/42 (levels 39 and 40 are not accessible as office space). This spares someone in the lower half of the building from having to go back to the ground floor to go to the upper half of the building.

The lifts contain a number of safety features. It is possible to evacuate people from a lift stuck between floors by manually driving one of the adjacent lifts next to it and opening a panel in the wall.. During an evacuation of the buildings, only the shuttle lift is allowed to be used, as <https://assignbuster.com/a-study-on-the-petronas-towers-construction-essay/>

there are only doors at levels G/1 and levels 41/42; therefore should there be a fire in the lower half of the building, this enclosed shaft would remain unaffected. Firefighter lifts are also provided in case of emergency

14. MATERIALS USED

The ' composite' structure of the Towers employs both the flexibility of steel and the rigidity of high-strength concrete. Each component material was used to best effect in constructing the 452 m-high buildings. About 80, 000 cubic meters of high strength concrete with 37, 000 tons of steel were used to form the frames of both Towers. Of particular importance was maintaining the verticality of the structures throughout the full height as they were being built. The reasons for this, besides reinforcing the aesthetic design, were to ensure structural load integrity and the safe passage of the high-speed double-decker elevators.

The determination of verticality was monitored by international specialist surveyors who, with the aid of global positioning systems, checked alignments every day and every night. The same surveyor used the same instrument at the same time in every 24 hours, thereby minimizing any element of differences in judgment. Construction works were done primarily at night and finishing works were done primarily during the day (to minimize the cost of artificial lighting).

As a result, the entire management and construction team redefined the Malaysian industry standard of ' fast-track'. The PETRONAS Twin Towers were finally encased in steel and glass and could be viewed as complete in June 1996. The construction process also drew extensively from the local

industry, with the finished towers having over 60 percent local material content. Malaysian made items included raw materials such as concrete and timber; finishing materials such as marble, ceramic tiles and glass; pre-fabricated materials including dry-walls, doors, suspended ceilings, and metal decking; equipment ranging from escalators to light fittings and sanitary ware; also furniture of all types from work-stations to custom-designed suites. Much of these materials were used in the process of internal finishing, which was then the focus of work teams until the end of 1996. The PETRONAS Towers complex is the tallest building on Kuala Lumpur's horizon, symbolizing Malaysia's determination to be a forward looking and technologically developed country.

15. RECORD BREAKING

Since they were constructed in 1997 the towers have held the world record as the highest twin building on land. Until 2004, when they were eclipsed by Taipei 101 in Taiwan, they were the world's highest building. In spite of being built by different companies the towers are exactly the same height standing at 452m. The Towers are built from super-high strength reinforced concrete, which is reputed to reduce the sway that tall buildings are prone to. However this made the building twice as heavy as a traditional reinforced steel building, necessitating extra deep foundations - 120m.

16. COMPARISION WITH OTHER TOWERS

Several other buildings are technically taller than the PETRONAS Towers.

The Sears Tower has 110 floors, but is only 442 meters tall. The Shanghai World Financial Center has 101 floors, and is 492 meters tall. The Taipei 101 Tower has 101 floors and is 509 meters tall. As of 2009 several other

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buildings are proposed or under construction that will be taller. The proposed Lotte World II in South Korea would be 512 meters tall with 107 floors. The Burj Dubai is under construction and is planned to be an astounding 818 meters tall with 162 floors.

The PETRONAS Twin Towers were the tallest buildings in the world until Taipei 101 was completed in 2004, as measured to the top of their structural components . Spires are considered integral parts of the architectural design of buildings, to which changes would substantially change the appearance and design of the building, whereas antennas may be added or removed without such consequences.

The PETRONAS Twin Towers, in Kuala Lumpur, Malaysia were the world's tallest buildings from 1998 to 2004, when their height was surpassed by Taipei 101. The towers remain the tallest twin buildings in the world.

Figure

Building & Location

Year

Stories

Height

Chief

Architect

M.

Ft.

Burj Khalifa (Burj Dubai, or Dubai Tower),

Dubai, UAE

2010

162

828

2, 717

Skidmore, Owings & Merrill

Lotte World II

Busan S. Korea

(proposed)

2013?

110

510. 55 m

1, 680

Stephan Huh, Parker Design International

Taipei 101 Tower

Taipei, Taiwan

2004

101

509

1, 670

C. Y. Lee & Partner

Shanghai World Financial Center, China

2008

101

492

1, 614

Kohn Pedersen Fox

International Commerce Centre (ICC), Hong Kong, China (under construction)

2010

118

484

1, 587. 9

Kohn Pedersen Fox

Xujiahui Tower, Shanghai, China

(proposed)

2010

92

460

1, 509

John Portman & Associates

PETRONAS twin towers

1998

88

452

1, 483

Cesar Pelli

17. SUMMARY AND CONCLUSIONS

The research and knowledge in concrete gained in the first half of the twentieth century benefit technologies today. This paper has provided a broad overview of different historic developments for concrete high-rise buildings. To summarize, the first users of concrete date before 1200 BC and include societies like the Phoenicians, Minoans, and Egyptians, to name only a few. The late 1700s and early 1800s found a renewed discovery of and interest in reinforced concrete as a building structure.

Americans and Europeans used it in large warehouses, factory buildings, apartment buildings and homes. New delivery systems, changes in

formwork, high-strength concrete and other admixtures were invented which improved concrete's strength and workability. Structural systems which go beyond the traditional post-and-beam construction of the Ingalls Building and the introduction of high-strength concrete mixes have together allowed reinforced concrete skyscrapers to grow to heights of the PETRONAS Towers and the Jin Mao Building never dreamed of in Elzner's and Ransome's day.

Little more than a century ago, reinforced concrete was invented. In that short period of time, reinforced concrete has gone from being a very limited material to one of the most versatile building materials available today. The first reinforced concrete buildings were heavy and massive. Valuable floor space was taken up by the massive concrete structural systems.

Today, due to our increased knowledge and improved technology, reinforced concrete buildings can be tall, graceful and elegant. Due, in part, to the use of shear walls, innovative structural systems and ultimate strength design, very little usable floor space is occupied by the structure. HSC and lightweight structural concrete allow us to use smaller member sizes and less steel reinforcement.

Because of the rapid developments of concrete construction and technology, with every passing year the use of concrete for tall buildings is becoming a constant reality. The mold ability of concrete is a major factor in creating exciting building forms with elegant aesthetic expression. Compared to steel, concrete tall buildings have larger masses and damping ratios that help in minimizing motion perception. A heavier concrete structure also provides better stability against overturning caused by lateral loads.

New structural systems including the composite ones that are popular now have allowed concrete high-rises to reach new heights during the last four decades.

Although steel will continue to be the structural material of choice for many tall buildings for its strength and ductility, we may expect to see more and more concrete and composite high-rise structures shaping the skylines of major cities of the world in the forthcoming years.