Construction developments in high rise buildings

This paper has provided a broad overview of different historic developments for concrete high-rise buildings. The evolution of concrete skyscrapers from the first reinforced concrete high-rise, the Ingalls Building, which was 15 stories high to modern skyscrapers PETRONAS Towers is discussed. How new innovations in construction technology such as the advances, techniques that are used to improve quality have all contributed to the ease of working with concrete in high-rise construction is also briefly discussed in the paper.

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.

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.

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.

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 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 collegues Aris Battista and Princess D Battista.

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 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.

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.

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.

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.

The towers feature askybridgebetween 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 170m

(558ft) above the ground and 58m (190ft) 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.

The lifts contain a number of safety features. It is possible to evacuatepeople 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 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

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 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.

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.