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Skyscrapers Construction Technology: A BIM Approach

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Abstract
Over the last ten years, the city of London and other cities of the western world have seen a significant densification and the provision of tall buildings. It is not perceived that many of the innovative techniques associated with the delivery of these buildings have been directly attributable to working in a BIM environment but, notwithstanding this, the BIM environment has brought greater opportunities in planning and communication of construction intent. It is to this end that this paper examines the BIM Approach involved in Skyscrapers Construction Technology. The Study reviewed existing works on Skyscrapers Construction Technology, a brief history of Skyscrapers design and Construction, the meaning of BIM and its features, application of BIM in Skyscrapers Construction and a Case Study of BIM Implementation in Shanghai Tower. Recommendations were made, and the paper concluded on the note that BIM makes the entire building process simpler and more efficient.

Introduction

A *skyscraper* is a tall, continuously habitable building of over 10 floors, mostly designed for office, commercial and residential uses. A *skyscraper* can also be called a high-rise, but the term *skyscraper* is often used for buildings higher than 50 m (164 ft). For buildings above a height of 300 m (984 ft), the term *Supertall* can be used, while skyscrapers reaching beyond 600 m (1,969 ft) are classified as *Megatall*.

BIM (Building Information Modeling) is an intelligent model based process that helps make design, engineering, project and operational information accurate, accessible and actionable for buildings and infrastructure. "According to Bon the Project Manager for AEC and Infrastructure at Autodesk. " Using a BIM Methodology improves collaboration and ensures a new level of control over projects of all sizes," said Vitelli. "Better project outcomes are achieved through a complete flow of information among applications. Just like information the model is crucial to the overall BIM process. It sets the stage for the overall project, contains all of the virtual equivalents to the building's parts and pieces and invokes the practical applications of these pieces.

In order to create, manage and distribute highly detailed and information rich 3D models, designers are turning to BIM. The software interfaces with other solutions and Manufacturing Machinery, enhancing workflow and avoiding errors. BIM is also used to integrate different designs, provide analytics, generate documentation, and help identify and solve issues in the design phase before construction. The Burj Khalifa in Dubai, the world's tallest tower at 828 meters has been the most complex Skyscraper to use Teka's BIM Software. Teka's BIM Software enabled Eversendai to model the Burj Khalifa's structural behaviour during high winds and Earthquakes, redistribute the gravity load to the bulding's extremities, manage the floor framing system and develop the highly durable concrete foundation to protect against water and corrossive soil conditions.

Eversendai also chose Teka's BIM Software for the Capital Gate Tower in Abu Dhabi, the World most inclined tower leaning at 18 degrees; and the 230 – meter Samba Financial Group Headquarters in Riyadh. Elsewhere in the Middle East, Teka's BIM Software has been used by steel contractors, William Hare for the Aldae Headquarters in Abu Dhabi, the first spherical building in the Middle East; Tiger Steel Engineering for the 380 – meter Elite Tower in Dubai, the world's 21st tallest building and the Middle East Sixth tallest; and Energya Steel Company's Headquarters in Egypt.

Paul Wallet, Area Business Director Tekia Middle East, said "As Architectural designs change rapidly in the Middle East Model- Based Software like BIM provides an intelligent way for changes to be visualized immediately. Our goal is for our customers to use BIM to reach high levels of productivity and quality, in order to remain competitive in thier fields".

Aim of the Project

The aim of this project is to find out the possibility of using the BIM Technology in enhancing Skyscrapers construction.

Objectives of the Project

The objectives shall include:

- Using the BIM Technology to determine the appropriate locations, numbers and sizes of the different structural components of the skyscraper for enhanced construction completion time.
- To determine the different building components on each floor level, for easy costing.
- The BIM Technology should be able to identify without much difficulty the structural walls, curtain walls, and the frame structures that are in allighnment within floors of the skyscraper for easy construction.
- Identifying errors on the drawings of any floor using the BIM technology.

Statement of Reserach Problem:

The science of tall building design is evolving rapidly to match increasing demand. As structures become higher and develop increasingly complicated geometry, structural engineers are challenged more and more to push the limits of what is possible. This calls for the use of more inclusive approach in enhancing the construction of Skyscrapers.

Significance of the Project

The new crop of high-rises presents purposeful symbols of wealth and power to which the rest of us cannot answer. These towers also have none of the qualities that made their predecessors beautiful, distinctive and, in the many interpretations and associations they evoked, powerful symbols of our aspirations or hubris. These towers tend to thrust up with the best, each proclaiming itself to be what Louis Sullivan calls "a proud and soaring thing."

However the ability of our engineers and all concerned in the building construction Industry to be able to easily construct these symbolic landmarks is key to this paper.

Literature Review

Brief History of Skyscrapers Design & Construction:

Several Technological Advances occured in the late nineteenth century that combined to make Skyscraper design and construction possible. Among them were the ability to mass produce steel, the invention of safe and efficient elevators, and the development of improved techniques for measuring and analyzing structural loads and stresses. During the 1920's and 1930's, Skyscraper development was further spured by invention of electric arc welding and flourescent light bulbs (their bright light allowed people to work farther from windows and generated less heat than incandescent bulbs).

Traditionally, the walls of a building supported the structure, the thicker the walls had to be a 16 – story building constructed in Chicago in 1891 had walls 6ft (1.8m) thick at the base. The need for very thick walls was eliminated with the invention of steel – frame construction, in which a rigid steel skeleton supports the building's weight, and the outer walls are merely hung from the frame almost like curtains. The first building to use this design was the 10 – story Home Insurance Company Building which was constructed in Chicago in 1885. The 792- ft (242-m) tall Woolworth Building, erected in New York City in 1913, first combined all of the components of a true Skyscraper. Its steel skeleton rose from a foundation supported on concrete pillars that extended down to bedrock (a layer of solid rock strong enough to support the building), it's frame was braced to resist expected wind forces; and it's high speed elevators provided both Local and express service to it's 60 floors. In 1931, the Empire State Building rose in New York City like 1,250 ft (381-m) exclamation point. It would remain the World's tallest office building for 41 years.

Construction Technology of Skyscrapers

The Construction Process: Each skyscraper is a unique structure designed to conform to physical constraints imposed by factors like geology and climate, meet the needs of the tenants and satisfy the aestethic objectives of the owner and the Architect. The construction process for each building is also unique. The following steps give a general idea of the common construction techniques.

A workman on the framework of the Empire State Building
Source: https://en.wikipedia.org/wiki/Skyscraper_design_and_construction

The Substructure:

1. Construction usually begins with digging a pit that will hold the foundation. The depth of the pit depends on how far down the bedrock lies and how many basement levels the building will have. To prevent movement of the surrounding soil and to seal out water from around the foundation site, a diaphram wall may be constructed before the pit is dug. This is done by digging a deep narrow trench around the perimeter of the planned pit; as the trench is dug, it is filled with slurry (watery clay) to keep it's walls from collapsing. When a section of trench reaches the desired depth, a cage of reinforcing steel is lowered into it. Concrete is then poured into the trench, displacing the lighter slurry. The slurry is recovered and used again in other sections of the trench.
2. In some cases, bedrock lies close to the surface. The soil on top of the bedrock is removed, and enough of the bedrock surface is removed to form a smooth, level platform on which to construct the buildings foundation. Footings (holes into which the buildings support columns can be anchored) are blasted or drilled in the bedrock. Steel or Reinforced concrete columns are placed in the footings.
3. If the bedrock lies very deep, piles (vertical beams) are sunk through the soil until they are embedded in the bedrock. One technique involves

driving steel piles into place by repeatedly dropping a heavy weight on thier tops. Another technique involves drilling shafts through the soil and into the bedrock, inserting steel reinforcing rods, and then filling the shafts with concrete.

4. A foundation platform of reinforced concrete is poured on top of the support columns.

The Superstructure and Core

Once construction of a Skyscraper is underway, work on several phases of the structure proceeds simultaneously. For example, by the time the support columns are several stories high, workers begin building floors for the lower stories. As the columns reach higher, the flooring crews move to higher stories, as well , and finishing crews begin working on the lowest levels. Overlapping these phases not only makes the most efficient use of time, but it also ensures that the structure remains stable during construction.

5. If steel columns and cross bracing are used in the building, each beam is lifted into place by a crane. Initially, the crane sits on the ground; later it may be positioned on the highest existing level of the steel skeleton itself. Skilled workers either bolt or weld the end of the beam into place (rivets have not been used since the 1950's). The beam is then wrapped with an insulating jacket to keep it from overheating and being weakened in the event of a fire. As an alternative heat – protection measure in some buildings, the steel beams consist of hollow tubes; when the superstructure is completed, the tubes are filled with water, which is circulated continously throughout the lifetime of the building.
6. Concrete is often used for constructing a buildings core, and it may also be used to construct support columns. A technique called "Slip Forming" is commonly used. Wooden forms of the desired shape are attatched to a steel frame which is connected to a climbing jack that grips a vertical rod. Workers prepare a section of reinforcing steel that is taller than the wooden forms. Then they begin pouring concrete into the forms. As the concrete is poured, the climbing jack slowly and continously raises the formwork. The composition of the concrete mixture and the rate of climbing are coordinated so that the concrete at the lower range of the form has set before the form rises above it. As the process continues, workers extend the reinforcing steel grid that extends above the

formwork and add extensions to the vertical rod that the climbing jack grips. In this way, the entire concrete column is built as a continous vertical element without joints.

7. In a steel- skeleton building, floors are constructed on the layers of horizontal brazing. In other building designs, floors are supported by horizontal steel beams attatched to the buildings core and or support columns. Steel decking (Panels of thin corrugated steel) is laid on the beams and welded in place. A layer of concrete, about 2 – 4 inches (5-10cm) thick, is poured on the decking to complete the floor.

Basic design considerations in Skyscrapers Design & Construction

Good structural design is very important in most building designs, but particularly for skyscrapers since even a small chance of catastrophic failure is unacceptable given the high prices of construction. This presents a paradox to civil engineers: the only way to assure a lack of failure is to test for all modes of failure, in both the laboratory and the real world. But the only way to know of all modes of failure is to learn from previous failures. Thus, no engineer can be absolutely sure that a given structure will resist all loadings that could cause failure, but can only have large enough margins of safety such that a failure is acceptably unlikely. When buildings do fail, engineers question whether the failure was due to some lack of foresight or due to some unknowable factor.

Loading and vibration:

Taipei 101 endures a typhoon (2005) Source:https://en.wikipedia.org/-wiki/Skyscraper-design_and_construction

The load a skyscraper experiences is largely from the force of the building material itself. In most building designs, the weight of the structure is much larger than the weight of the material that it will support beyond its own weight. In technical terms, the dead load, the load of the structure, is larger than the live load, the weight of things in the structure (people, furniture, vehicles, etc.). As such, the amount of structural material required within the lower levels of a skyscraper will be much larger than the material required within higher levels. This is not always visually apparent. The Empire State Building's setbacks are actually a result of the building code at the time, and were not structurally required. On the other hand, John Hancock Center's shape is uniquely the result of how it supports loads. Vertical supports can come in several types, among which the most common for skyscrapers can be categorized as steel frames, concrete cores, tube within tube design, and shear walls. The wind loading on a skyscraper is also considerable. In fact, the lateral wind load imposed on super-tall structures is generally the governing factor in the structural design. Wind pressure increases with height, so for very tall buildings, the loads associated with wind are larger than dead or live loads. Other vertical and horizontal loading factors come from varied, unpredictable sources, such as earthquakes.

Shear walls

A shear wall, in its simplest definition, is a wall where the entire material of the wall is employed in the resistance of both horizontal and vertical loads. A typical example is a brick or cinderblock wall. Since the wall material is used to hold the weight, as the wall expands in size, it must hold considerably more weight. Due to the features of a shear wall, it is acceptable for small constructions, such as suburban housing or an urban brownstone, to require low material costs and little maintenance. In this way, shear walls, typically in the form of plywood and framing, brick, or cinderblock, are used for these structures. For skyscrapers, though, as the size of the structure increases, so does the size of the supporting wall. Large structures such as castles and cathedrals inherently addressed these issues due to a large wall being advantageous (castles), or ingeniously designed around (cathedrals). Since skyscrapers seek to maximize the floor-space by consolidating structural support, shear walls tend to be used only in conjunction with other support systems.

Steel frame

The classic concept of a skyscraper is a large steel box with many small boxes inside it. The genius of the steel frame is its simplicity. By eliminating the inefficient part of a shear wall, the central portion, and consolidating support members in a much stronger material, steel, a skyscraper could be built with both horizontal and vertical supports throughout. This method, though simple, has drawbacks. Chief among these is that as more material must be supported (as height increases), the distance between supporting members must decrease, which actually, in turn, increases the amount of material that must be supported. This becomes inefficient and uneconomic for buildings above 40 stories tall as usable floor spaces are reduced for supporting column and due to more usage of steel.

Tube frame

Since 1963, a new structural system of framed tubes appeared. Fazlur Khan and J. Rankine defined the framed tube structure as "a three dimensional space structure composed of three, four, or possibly more frames, braced frames, or shear walls, joined at or near their edges to form a vertical tube-like structural system capable of resisting lateral forces in any direction by cantilevering from the foundation." Closely spaced interconnected exterior columns form the tube. Horizontal loads (primarily wind) are supported by the structure as a whole.

Tube (structure)

The Willis Tower showing the bundled tube frame design
Source: https://en.wikipedia.org-/wiki/Skyscraper-design-and-construction

About half the exterior surface is available for windows. Framed tubes allow fewer interior columns, and so create more usable floor space. Where larger openings like garage doors are required, the tube frame must be interrupted, with transfer girders used to maintain structural integrity. Tube structures cut down costs, at the same time allow buildings to reach greater heights. Tube-frame construction was first used in the DeWitt-Chestnut Apartment Building, designed by Khan and completed in Chicago in 1963. It was used soon after for the John Hancock Center and in the construction of the World Trade Center.

A variation on the tube frame is the bundled tube, which uses several interconnected tube frames. The Willis Tower in Chicago used this design, employing nine tubes of varying height to achieve its distinct appearance. The bundle tube design was not only highly efficient in economic terms, but it was also "innovative in its potential for versatile formulation of architectural space. Efficient towers no longer had to be box-like; the tube-units could take on various shapes and could be bundled together in different sorts of groupings." The bundled tube structure meant that "buildings no longer need be boxlike in appearance: they could become sculpture." Cities have experienced a huge surge in skyscraper construction, thanks to Khan's innovations allowing economic skyscrapers.

The tubular systems are fundamental to tall building design. Most buildings over 40-stories constructed since the 1960s now use a tube design derived from Khan's structural engineering principles, examples including the construction of the World Trade Center, Aon Centre, Petronas Towers, Jin Mao Building, and most other supertall skyscrapers since the 1960s. The strong influence of tube structure design is also evident in the construction of the current tallest skyscraper, the Burj Khalifa.

According to Bill Baker, the structural engineer for Skidmore, Owings & Merrill responsible for the Burj Khalifa, the trend towards taller, thinner buildings has presented new spins on old engineering challenges. When the ratio between the height and width of a building goes beyond 8 :1 or 9:1, it becomes increasingly more expensive to construct, since it requires thicker walls and more sophisticated technology to reduce the amount of swaying and shaking caused by the wind (Baker compared today's thinner supertalls to a fishing rod, and making one stand up straight requires much more reinforcement). The height-to-width ratio for 432 Park Avenue is 15:1; to put that in perspective, if you place a standard ruler on its end, it has a ratio of 12:1.

"Confusing the Wind"

Wind is the "dominant force" in tall buildings, says Baker. Over time, engineers and architects have become more and more sophisticated when it comes to shaping a building to account for gusts that can, on very rare days, reach 100 miles-per-hour at the crown of a 90- or 100-story skyscraper. Early in the design process, different shapes for a proposed tower are workshopped and run through wind tunnel testing to determine which one is most efficient. Computer simulations for complex wind patterns still take a long time, so model testing often works best to determine factors such as lift and cross-breezes. Baker says, "the wind tunnel is a giant calculator." Skyscraper designers want to "confuse the wind," says Baker. Air pushing against the surface of a tall tower creates vortices, concentrated pockets of force that can shake and vibrate buildings (the technical term is vortex shedding). The aim of any skyscraper design is to break up these vortices. Facades often have rounded, chamfered or notched corners to help break up the wind, and sometimes, open slots and grooves will be added to let wind pass through and vent, in effect disrupting the air flow. "It's interesting that the aerodynamics of the building are almost counterintuitive," says DeSimone. "We don't want smooth shapes, we want shapes that break up the air flow."

Dampers: Shock Absorbers for Supertalls

To help counter the shifting and swaying of building, engineers also utilize **dampers**, massive devices that shift and help stabilize tall structures like counterweights. Think of them like the weights in a grandfather clock; engineers attach 300-800 ton pieces of steel or concrete on a floor near the top of a tower, tuning and adjusting chains to balance them so they move out of phase with local wind patterns, steadying the tower. Two main types of dampers are used today; tuned mass dampers, which function like swinging pendulums, and slosh dampers, or slosh tanks, large pools of water that help absorb vibrations. The technology isn't new; it's been used on buildings such as the Seagram Tower, completed in 1958. But it's become more common and more sophisticated. Some tuned mass dampers even use actuators, or small motors, to shift and move in opposition to the wind. The engineers of the Shanghai Tower even devised a damper system with powerful magnets. According to DeSimone, all this effort to limit the swaying of a building, which can cost upwards of $5 million per project, pays off. Top floors of buildings with these types of systems will only shift two-and-a-half feet during rare, incredibly strong, once a century gusts of wind, an amount that's imperceptible to the naked eye (though it can make people feel seasick).

"We Shouldn't Call It Concrete Anymore

Even with carefully engineered facades and vibration-canceling technology, supertalls still need to support massive amounts of weight. While we haven't moved past concrete and steel, technological advances means the elemental ingredients of skyscrapers can support much larger loads with much less material. "Concrete is amazing these days," says Baker. "We should call it something new, since it's so different than concrete from a few decades ago."

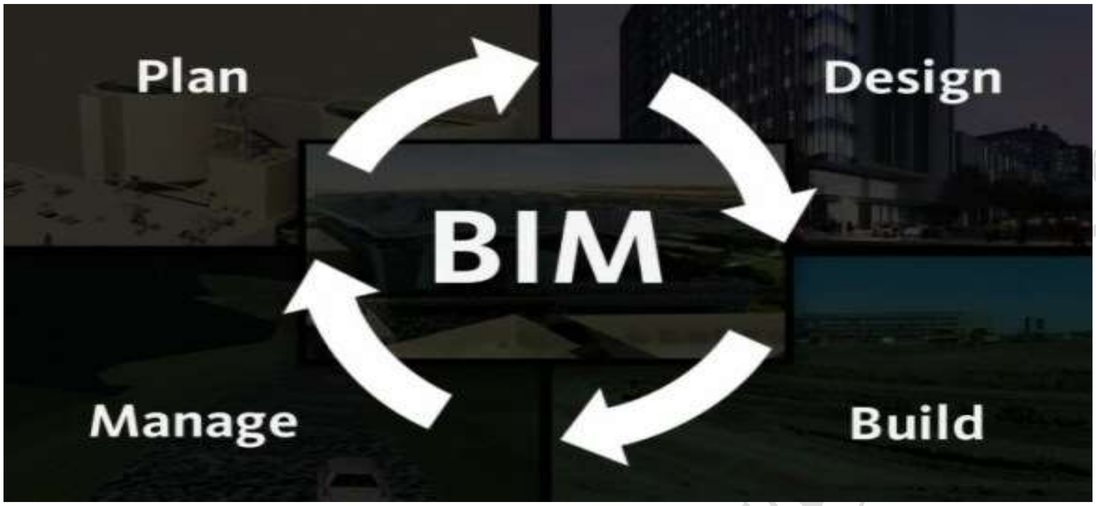
More workable and up to five times stronger, concrete today has gained these powers due to a more complex chemical composition. In many cases, industrial by-products, such as fly ash, slag from steel mills and microsilica left over from silicon manufacturing, are added to strengthen the mix, allowing it to be stiffer and support heavier loads.

Baker says that many building engineers are experimenting with composite structures that combine high-strength steel and concrete in different ways (concrete-filled steel tubes, for instance) to find the right balance of strength and flexibility. Where builders may have been limited in the past, stronger materials means they can build taller while maintaining the same size structural elements, according to DeSimone.

The most exciting part about these technical advances is that they promote unique designs. To explain, Baker compares the design process of buildings against that of cars. Since vehicles are all trying to solve a similar engineering issue in regards to wind and aerodynamics, car shapes have tended to move towards a uniform middle, and bear a much closer resemblance than they did decades ago. The opposite is happening with tall buildings; the combination of site-specific environmental factors, and the desire to make each supertall a signature part of a city's skyline, means towers will continue to evolve in different and creative ways.

Meaning of BIM and Its Features

Building Information Modeling (**BIM**) is a process involving the generation and management of digital representations of physical and functional characteristics of places. **Building Information Models** (**BIMs**) are files (often but not always in proprietary formats and containing proprietary data) which can be extracted, exchanged or networked to support decision-making regarding a building or other built asset. Current BIM software is used by individuals, businesses and government agencies who plan, design, construct, operate and maintain diverse physical infrastructures, such as water, wastewater, electricity, gas, refuse and communication utilities, roads, bridges, ports, tunnels, etc.



Features of Building Information Modeling (BIM) Services

1. Added dimensions:

The architects and other building professionals are used to the 3D CAD software that enable them to work in three dimensions, viz. height, width and depth, BIM has taken it further and added two more dimensions, namely cost and time. Structural BIM services provide the bills of materials and cost estimations along with desired views even while working on the design. Time schedules can be prepared and adhered to in a more efficient manner with the help of Building Information Modeling.

2. Virtual Information Model:

BIM enables the designers to hand over a virtual information model of the project to the Principal Contractor and other sub-contractors, and then subsequently this model is transferred to the owners or the operators of the facility. The architect, structural, civil and building services engineers, and surveyors etc, can make inputs regarding discipline specific data to the model which is shared by each stakeholder. Information losses at the time of project being handed over to a new team has always been a great problem, and BIM ensures that there are minimal information losses. A more extensive information database is now available for the owners of the complex structures, which often comes handy at a later stage.

3. All encompassing system:

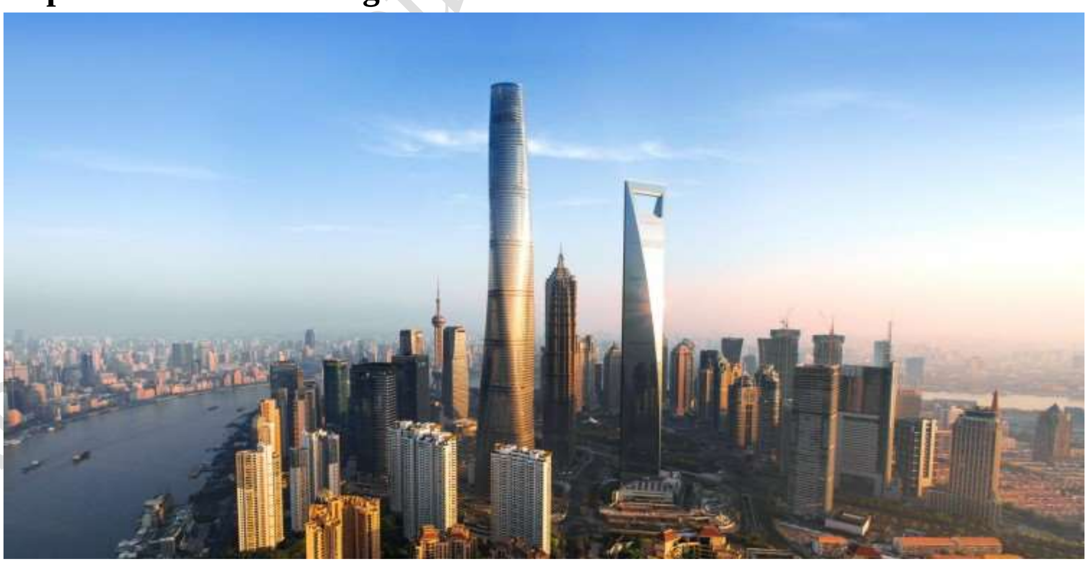
Unlike other existing modeling systems, involvement of BIM is not just till the design and construction stages of a structure, its usefulness extends throughout the building life cycle. Every single process involved from the initial design conceptualization to the demolition of the building, like cost management, construction management, project management and facility operation is supported by Building Information Modeling.

4. BIM Management:

BIM spans the entire life cycle of a structure, as mentioned above, right from the initial design conceptualization to its full occupancy tenure till its demolition. A BIM manager is essential to ensure efficient management of information systems during the complete building life cycle. The job of a BIM manager is specifically to develop and track the object oriented BIM against the projected performance objectives set by the stakeholders, to support multi-disciplinary building information models and help achieve an excellent end result.BIM Modeling services facilitate the owners in the building's maintenance even after the project is handed over.

Building information modeling is a powerful tool for the construction industry in the modern times and is seen as its future by the professionals across the globe. Despite being a complex system, it enables the stakeholders to make the entire building process simpler and more efficient.

Application of BIM in Skyscrapers Construction / Case Study of BIM Implementation in Shanghai Tower.



Shanghai Tower
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/

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Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Gensler.

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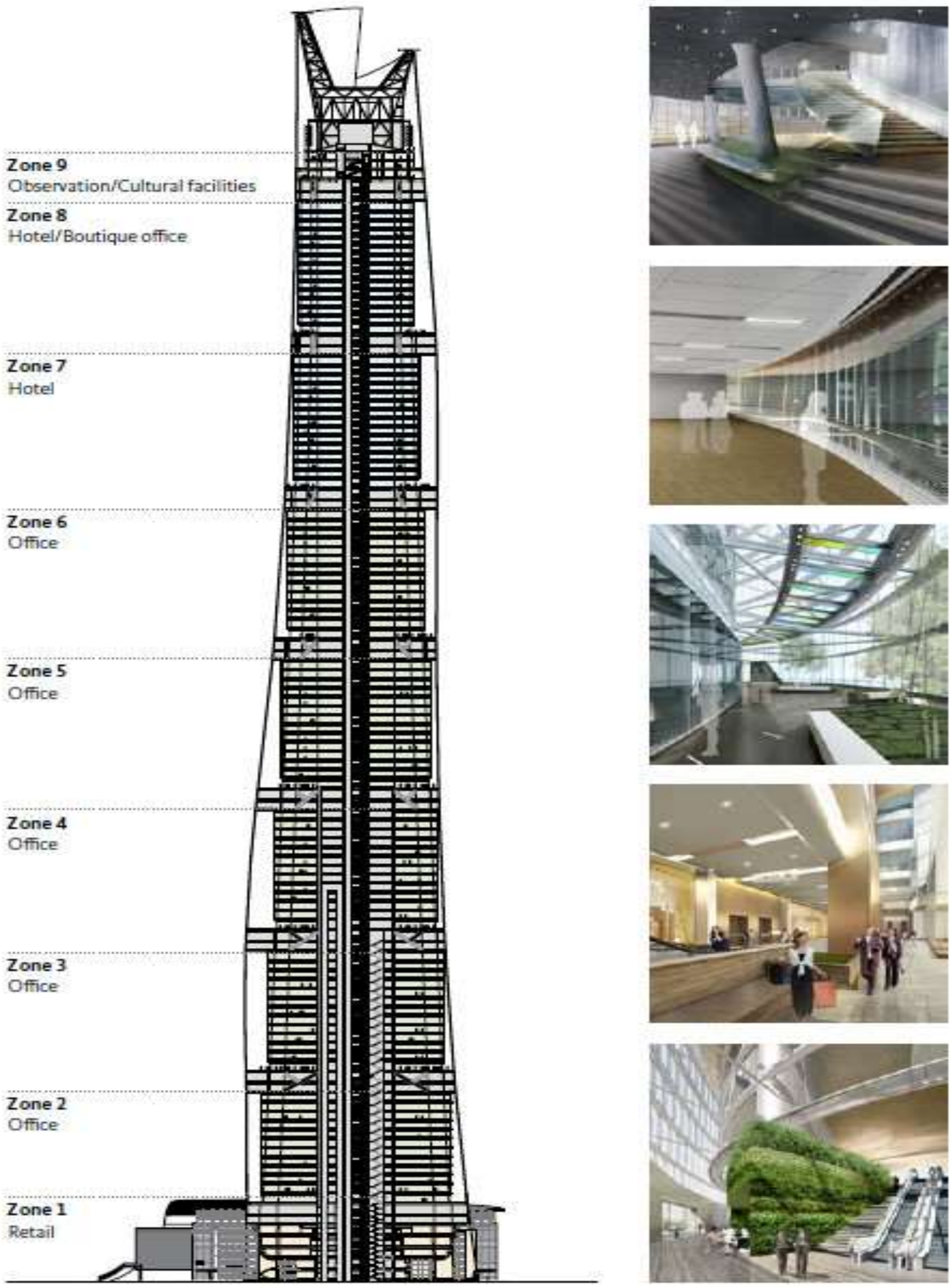

Shanghai Tower, Section and Interiors
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Gensler.

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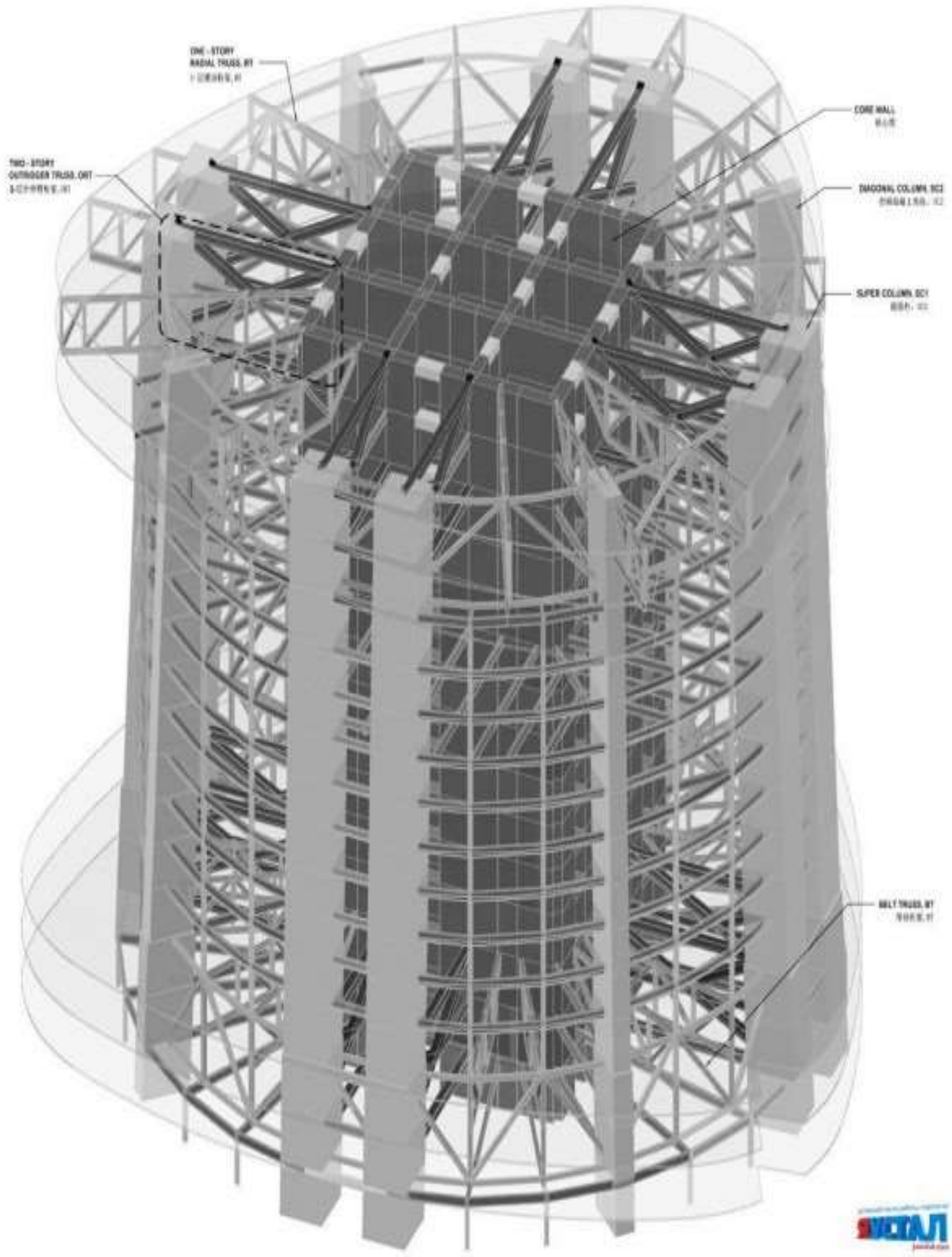
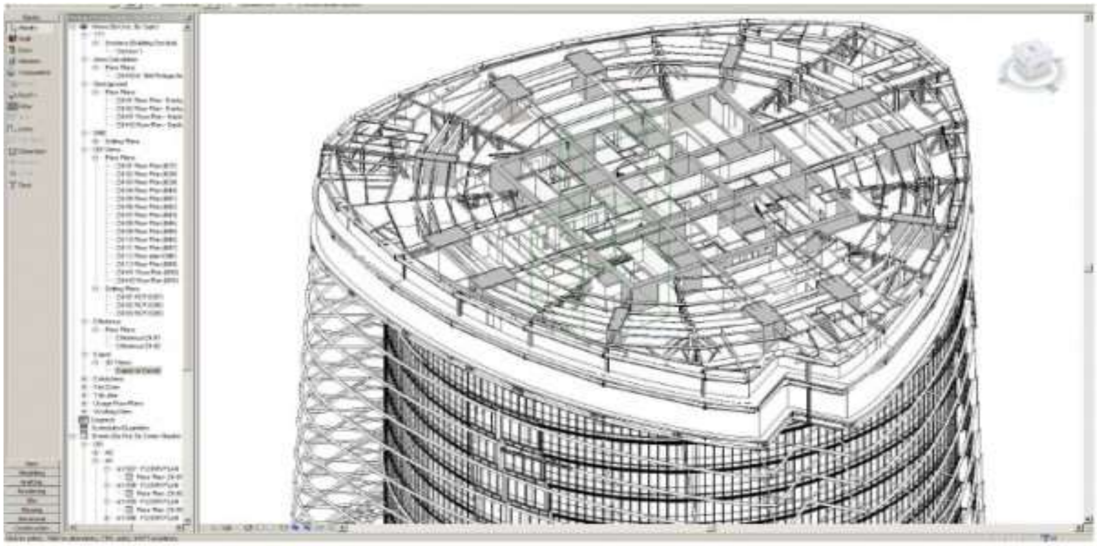


Shanghai Tower, the Skeketon
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Shanghai Tower Construction & Development.



Shanghai Tower,
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
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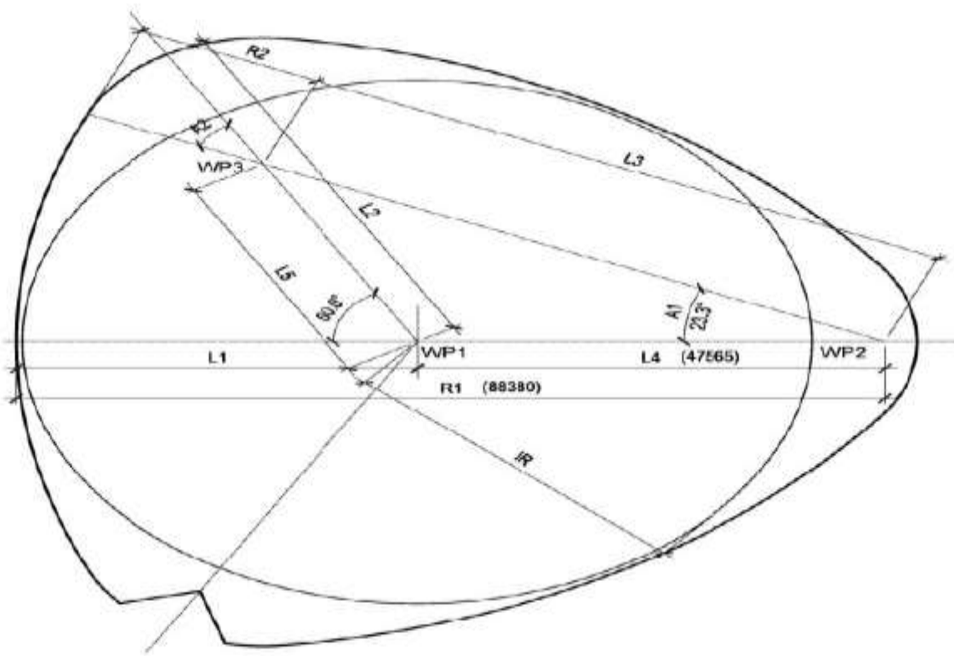
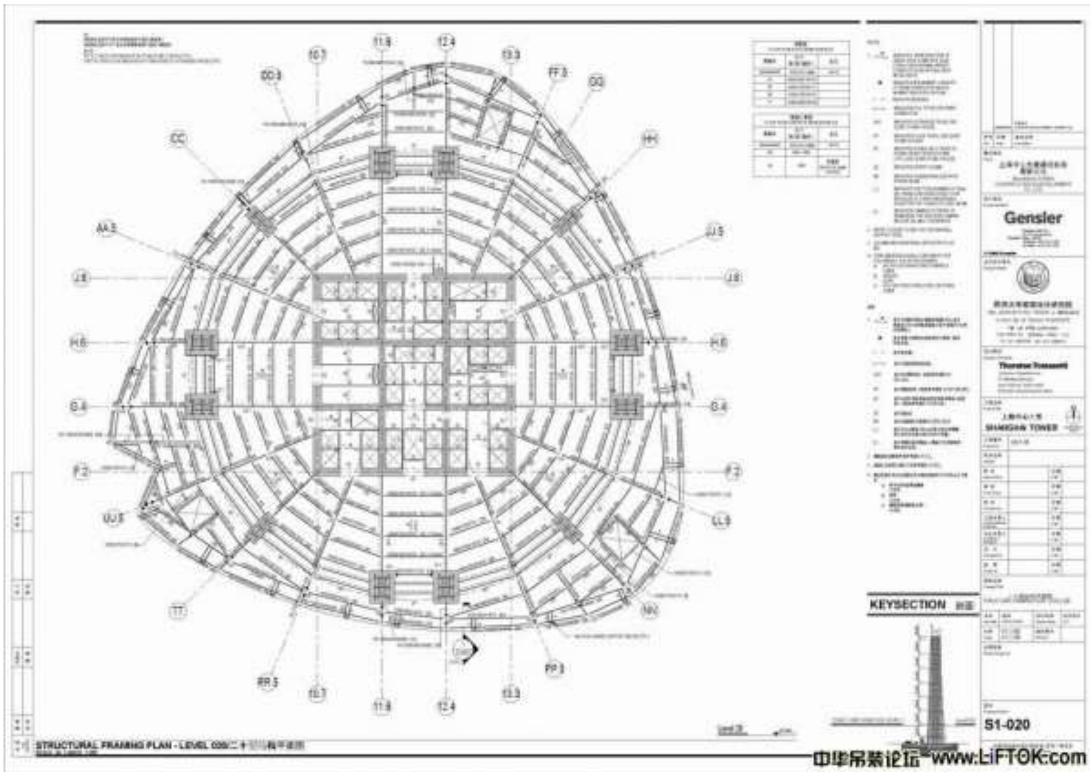
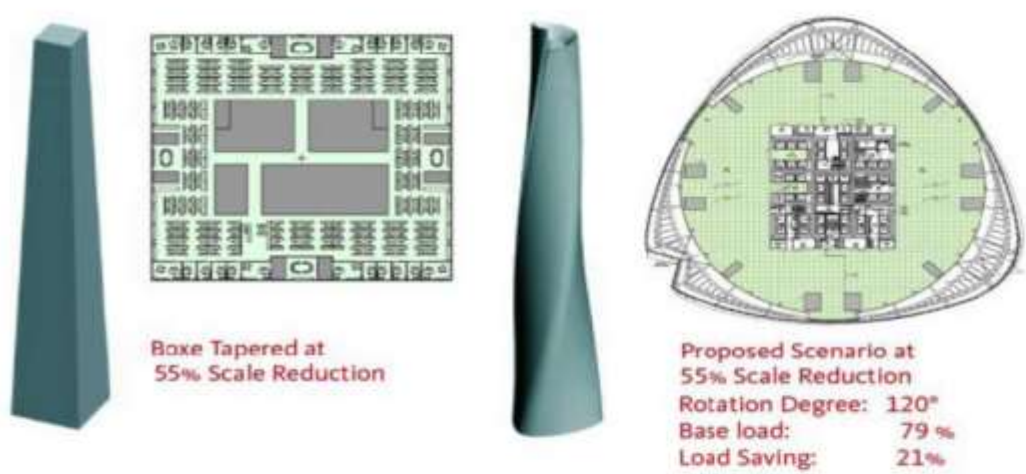


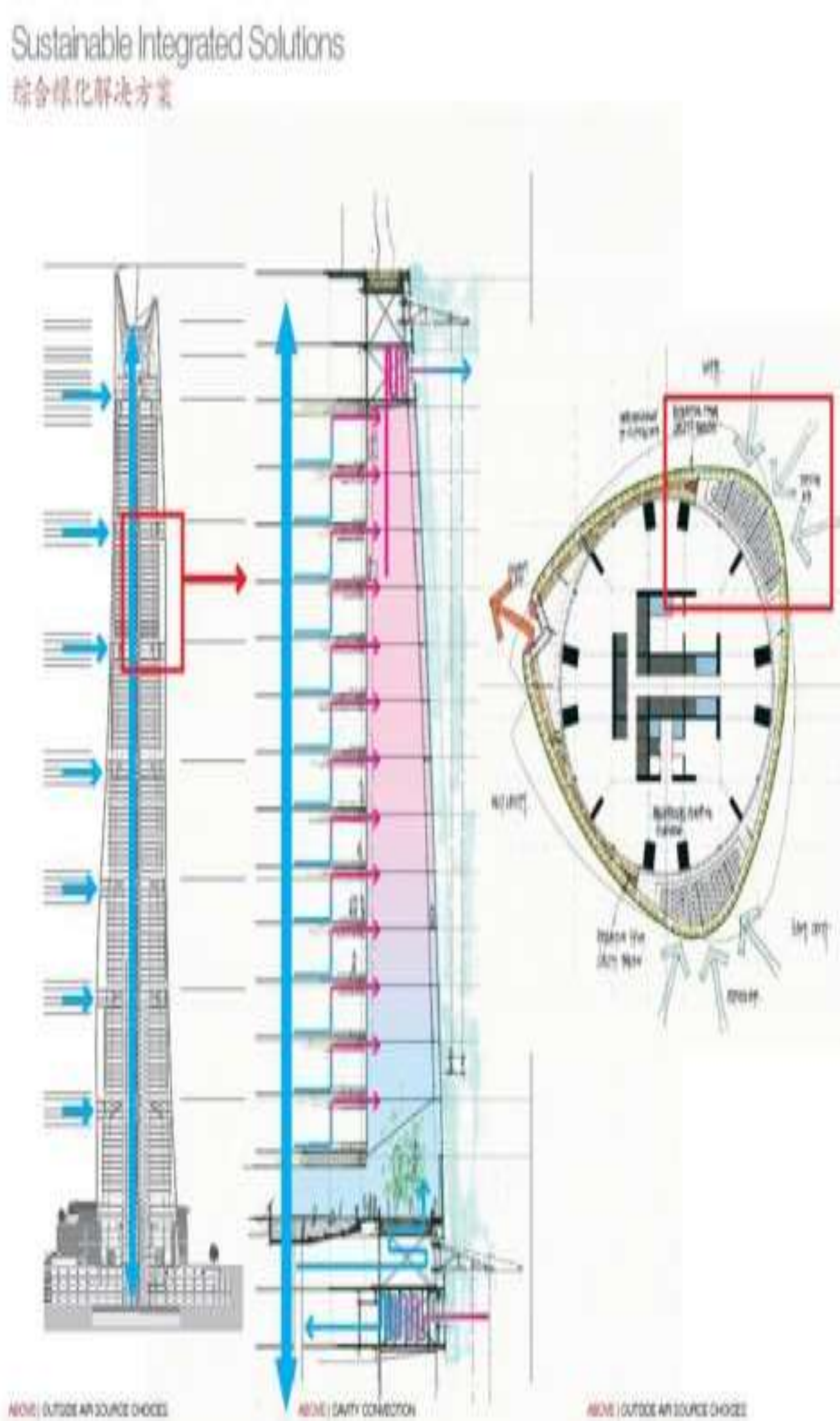
Shanghai Tower, Plan's Horizontal Profile
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Shanghai Tower Construction & Development.



Shanghai Tower, Plan's Horizontal Profile
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Shanghai Tower Construction & Development. Via Liftok.com

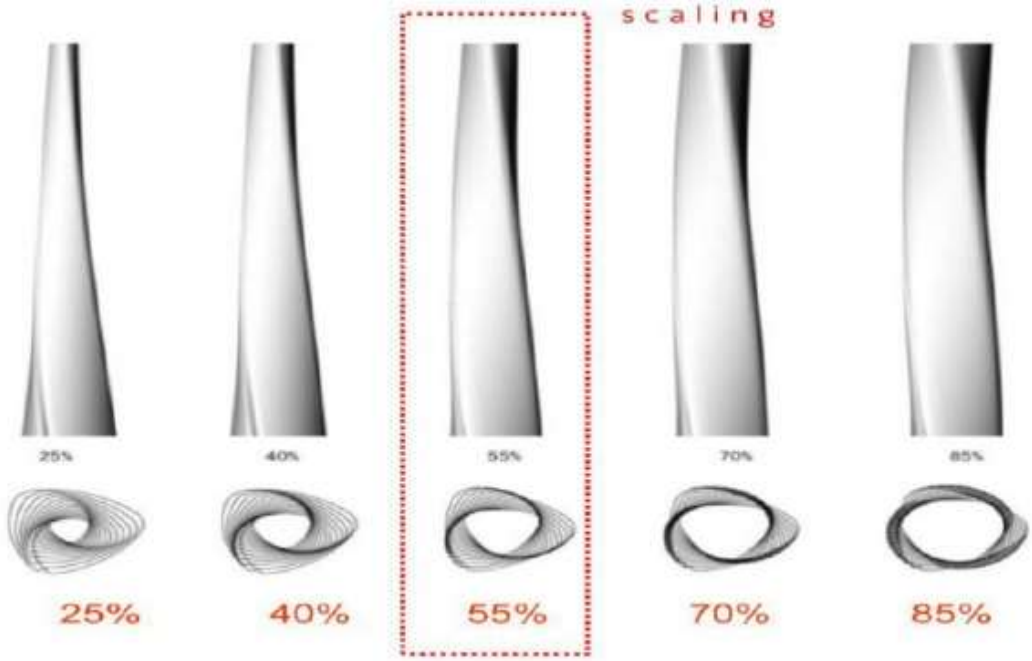


Shanghai Tower, Plan's Vertical Profile
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Gensler.



Shanghai Tower, Plan's Vertical Profile
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Shanghai Tower Construction & Development.

Shanghai Tower, Aerial View
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Shanghai Tower Construction & Development.



Shanghai Tower, Rate of Twist
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Gensler.

Shanghai Tower, a number of alternatives for the geometry depending on two variables: the percentage of tapering operation and the angle of twisting process.
Source: https://www.arch2o.com/case-study-bim-implementation-in-shanghai-tower/
Courtesy of Gensler.

- **Formulation of modeling rules**

  Uniform modeling rules regarding civil work, steel structure and MEP (Mechanical, Electrical & Plumbing). The minor building information models of individual specialties can be integrated into a major building information model to be applied to project management.

  (1) Uniform system of coordinates and initial point;

  (2) Standardized rules on designations and definitions of structural members;

  (3) Such attributes as building number, storey number and specialty title, assigned to each structural member.

- **Establishment of information platform**

  Huge volume of data may be shared via the BIM information platform, for design optimization, change management, node optimization, progress management, work face management, inter-specialty clash management, contract document management, and operation and maintenance management, to improve the detail sufficiency of general contract management

- **Real-time analysis and management of construction progress**

  A highly-feasible construction plan is automatically devised, taking into account the required quantities of workers, materials and machines as well as the required construction period, and referring to the work efficiency quota library and the quantities of construction. The actual construction progress is recorded and compared with the planned one. Construction progress warning activation conditions are set for each construction process and associated processes. In this manner, the construction progress is effectively managed.

- **Real-time analysis and management of cost**

  The quantities of construction are automatically calculated. State or enterprise-specified quotas are attached to the BIM model for construction cost estimation and control. Comparisons in three aspects: basic construction investment estimation, design budget estimation and budget estimation according to working drawings, cost market penetration analysis and solution cost optimization are performed via the BIM model.

- **Formation of central database**

  5D virtual construction is performed using the BIM technology, to enhance the on-site construction progress and cost management. General control analysis and management are performed via the central database to establish the performance library and quota library

The design and construction process of a megatall tower is very difficult and complicated project. Such projects need a proficient qualified project management that can coordinate effectively between the different teams. The Shanghai Tower is a considerable example of successfull outstanding management for this type of Skyscrapers. The tower is multi – functional building. It includes nine different functional zones with 7 structural systems and more than 30 electrical, mechanical and intelligent subsystems. It is a complicated structure that requires a large number of specialists and professions in different disciplines to come together. Hence the project employed more than 30 consulting companies in Architectural, Structure, Mechanical and Electrical Engineering, Fire protection, and curtain wall design. it also contracted with a dozen of subcontractors in foundation, structure and machinery. This huge number of employees and specialists put the project managers in front of a challenge to find the effective strategy for coordination system. They searched for an effective information technology that achieves a flexible unison between all disciplines through one united platform. For this goal, they adopted BIM technology. As we know, BIM Technology has proven lately valuable efficiency in systemization of different construction projects mainly in collaboration, coordination, and sharing data. It unifies the platform for all disciplines to share their design files. It is an effective information system that creates a database for all design and construction phases. This database considers the DNA of the building and can be a reference for future maintenance and development, for that reason Shanghai's Tower construction and Development, decided to employ this technology in operating the design, structure and construction processes of the Tower, Jianping Gu director and general manager of the company explains "We knew that if we tried to work in a traditional way, using traditional tools and delievery systems, it would be extremely difficult to carry out this project successfully."

Recommendations:

It is recommended from the forgoing that:-

i. Construction Companies involved in Skyscrapers Construction should adopt BIM as it utilizes a program that significantly improves the overall schedule and timing of a project which consequently saves time and money.

ii. As a method for planning, estimating and Coordinating, it will greatly benefit Clients down the line, should they need to expand their facilities in the future.

Conclusion:

Skyscrapers Construction is an enormous task and for such a task, the Construction team needs a technology that can help in its perfect execution. The use of BIM (Building Information Modeling) (Technology) is timely as time, energy, and Cost of the Project is saved and also a future for the Cities and Environments harboring these Architectural Edifices, sustained.

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Ivars Peterson (5 April 1986). "The first skyscraper – new theory that Home Insurance Building was not the first". CBS Interactive. Retrieved 6 January 2010. "In my view, we can no longer argue that the Home Insurance Building was the first skyscraper," says Carl W. Condit, now retired from Northwestern University in Evanston, Ill., and author of several books on Chicago architecture. "The claim rests on an unacceptably narrow idea of what constitutes a high-rise commercial building," he says."If there is a building in which all these technical factors—structural system, elevator, utilities—converge at the requisite level of maturity," argues Condit, "it's the Equitable Life Assurance Building in New York." Completed in 1870, the building rose 7½ stories, twice the height of its neighbors

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