

BIM Technologies Applied in Construction Phase of China Zun Tower



Project Overview

China Zun Tower is a super-tall and super-large project with the total investment of 3.5 billion USD. It is located on the central axis of Beijing's CBD and covers an area of 1.15 hectares. The construction area totals 437,000 square meters, with 350,000 square meters / 108 floors on the ground, 87,000 square meters / 7 floors underground. After completion, the 528m building will be the tallest in Beijing and become a new landmark of the city skyline. The construction was started in July 2013 and will be completed in October 2018.

The owner of this project is China International Trust and Investment Corporation (CITIC) Heye Investment Co. Ltd., a primary subsidiary of CITIC Group. Beijing Institute of Architecture Design (BIAD) works as the general designer. BIAD works with TFP Design Firm for conceptual design; KPF helps on this project as architectural advisor; Arup is structural advisor and PB is electromechanical advisor. The combo of China State Construction Engineering Corporation Ltd. (CSCEC) and China Construction Third Engineering Bureau Co., Ltd. (CCTEB) works as the general contractor.

China Zun Tower is a role model of BIM application in megasize and complex projects. BIM technology helps the skyscraper over 500m to be built within 62 months. The construction speed is 1.4 times of similar projects.

China Zun Tower is China's first intelligent construction project, which is fully empowered by BIM technology to synchronize design management, and to guide construction. BIM technologies are efficiently integrated to ensure crosssectoral alignment and collaboration, life-cycle simulation and life-cycle application.

Project challenges:

- The world's first skyscraper that stands on an area of 8 degree seismic fortification intensity (China standard for earthquake)

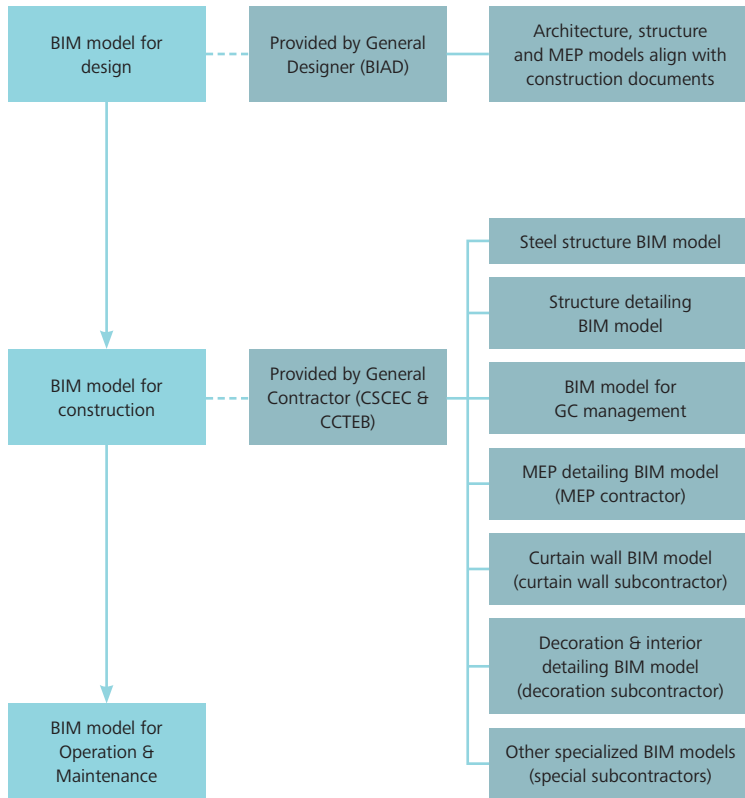
- Has the shortest construction period for a skyscraper over 500m, which is only 62 months.
- Is located at the heart of CBD in Beijing, leaving little space for construction site. The external wall of the building is extremely close to the property line;
- Holds the world's highest steel plate shear wall structure which is over 227m; and the largest concrete filled multi-cavity steel mega-column with cross-section area over 64m².
- Has super mass concrete slab with thickness of 6.5m, area of 1,1478m² and total concrete amount of 6,2000m³. It is the first time that HRB500 40 mm rebar is used in piled raft foundation. The pit is nearly 40 meters deep.
- Has unique styling, complicated structure and various systems. Detailing for and coordinating among different parts are difficult and demanding.








As General Contractor of China Zun Tower, we focus on technical innovation. We have applied 20+ new technologies on this project, among which BIM provides us evolutionary experience. We deeply work with designers and subcontractors based on BIM models. With BIM's advantage of information integration, we significantly increase efficiency and construction quality. And it also improves the team's capability to handle a super complicated project like this.

- Xu Lishan

Executive Chief Engineer & Construction Director of China Zun Tower
China Construction Third Engineering Bureau Co., Ltd



 AUTODESK® REVIT®	<ul style="list-style-type: none"> - Architecture, structure & MEP detailing - Decoration & interior design - Curtain wall design and other - Specialization design - 3D scanning data review
 AUTODESK® NAVISWORKS® MANAGE	<ul style="list-style-type: none"> - Model & information integration - Collision detection - 4D construction simulation - Schedule planning - 3D scanning data review
 AUTODESK® BIM 360™ GLUE®	<ul style="list-style-type: none"> - On-site construction inspection
 AUTODESK® DYNAMO STUDIO	<ul style="list-style-type: none"> - Fine decoration complex parts design & fabrication
 AUTODESK® RECAP PRO	<ul style="list-style-type: none"> - Generate BIM models for decoration design

The general contractor and subcontractors apply BIM technology to address the difficulties

1. BIM is adopted in design detailing of architecture, structure and MEP parts to develop and verify original designs. BIM detailing greatly improves efficiency and feasibility. Over 6,200 defects have been detected and fixed in time, cutting the load of on-site changes and modifications.
2. To satisfy construction quality requirements, the contractors use BIM to simulate complex steel structure connections for optimization. Mobile devices and 3D scanning are used to review and guide construction work on site based on the optimized BIM model.
3. The contractors introduce BIM for pre-fabrication and off-site digital processing of steel bars, curtain wall plates and electromechanical pipelines. This reduces the demand for construction space, and enables industrialized construction.
4. The contractors use Revit to design and manufacture steel bracket and use Navisworks to simulate/optimize the process of concrete pouring. Finally, it took 93 hours to complete concrete pouring of 5,6000m³, with 20% of time saving over traditional pump solution.

BIM application overview

The project owner CITIC Heye Investment advocates and leads lifecycle BIM application, which has been a mandate for all designers and contractors. BIM data are passed on from design to construction, operation and maintenance. After thorough studies and discussions by all parties involved, The Guide to BIM Execution in China Zun Tower was compiled, which set action guideline and standard for all parties during the project life cycle. With progress of the project, experience is accumulated, enabling the Guide to be improved and scaled up.

The BIM team for construction phase has over 100 staff from 28 departments covering 9 supporting functions of general contracting. BIM Management Department is the coordinator among internal functions, and the interface with project owner and designers for BIM application.

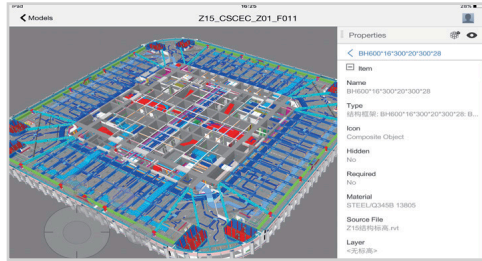
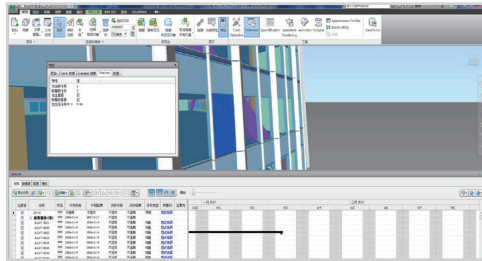
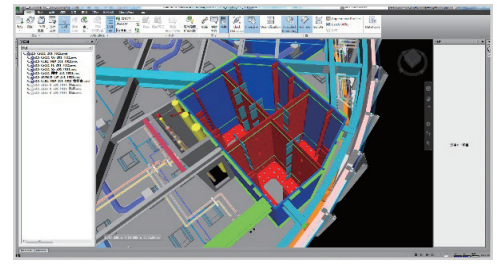
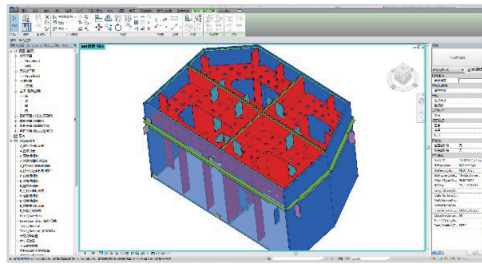
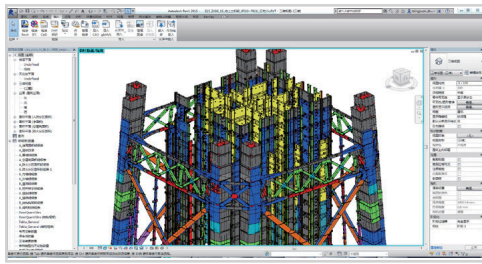
To facilitate model interoperability and data exchange, BIM Management Department of the General Contractor made the following requirements for the model format to be submitted:

- Deliverable Models: Models with original format, link models in Autodesk Revit format, and Autodesk Navisworks-bound browsing models;

- Editable models: based on Autodesk Revit platform to aggregate and integrate data of different formats;
- Browsing models: based on Autodesk Navisworks platform to integrate data of different formats;
- With consent of the project owner, models of other data format can be provided in original format, together with the Autodesk Navisworks models.

On top of common BIM applications, the team has innovated with superprecision detailing design, simulation of most challenging construction tasks, prefabrication of super volume structure, and 3D laser scanning.

Over 90% of model clashes can be addressed with BIM coordination. Rework and modification drop by 65% compared with traditional practice.



BIM Design Detailing for Coordination and construction guide

Detailing design aims at optimizing the functions and quality of the tower. All these measures help improve building quality and create additional value over one hundred million RMB.

The Guide to BIM Execution in China Zun Tower was compiled to specify LOD of detailing design and standards for each technical domain. In the detailing process, the specialized teams fully integrated 3D models with 2D drawings, to develop high-quality detailed design files. Up to date, the project has generated over 100,000 detailed design drawings. Precision of the steel structure, fine decoration, and curtain wall models has exceeded LOD400.

Some numbers up to the end of 2016.

652: A total of 652 detailing design models were developed in all specialized areas, Among them, decorative models take the largest share.

800: Over 800 Revit component families dedicated to this project were created by 10 professional subcontractors, covering specialized domains of electromechanics, fine decoration, curtain wall, elevator and window cleaning equipment.

806: 806 rounds of construction drawing reviews have been done, including steel structure, electro-mechanics, decoration, curtain wall and lift, fireprotection and other domains.

6200: With BIM tools, the project has run 6-7 times more multi-discipline coordination review. Over 5000 issues were found in design phase and over 6200 were found in construction.

7,200: By shortening window fan coils, 4,200 m2 was saved for other purpose. An additional 3,000 m2 was spared by optimizing layout of the standpipes in the tube-wells beside the giant pillars. In total, usable area was enlarged by 7,200 m2.

With high-precision design detailing models, general contractors effectively mobilize subcontractors and consultants, creating a comprehensive coordination pattern that features the leadership of general contractors, participation of all parties, and continuous updating. Software automatic calculation was combined with manual review by engineers to facilitate coordination. Then clashes that might impact operation or maintenance were saved with viewpoints in a report for correction.

It is estimated that over 90% of model clashes can be addressed after several rounds of coordination. Rework and modification drop by 65% compared with traditional practice, which helps save time and cost in construction.

During the construction, BIM managers organize regular on-site inspection to check compliance with BIM models using Autodesk BIM 360 Glue on iPad. BIM data is used at certain level in construction tasks such as tour-inspection, technical disclosure, QA/QC, etc. In case of inconsistency, the parties would draft a report for revision and execution. Greater consistency between models and construction enhances data quality for intelligent operation and maintenance. It simplifies the difficulty of construction management, reduce errors, saves times and improves efficiency.

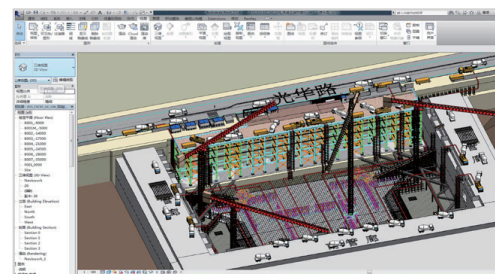
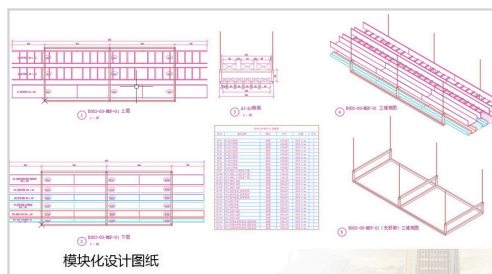
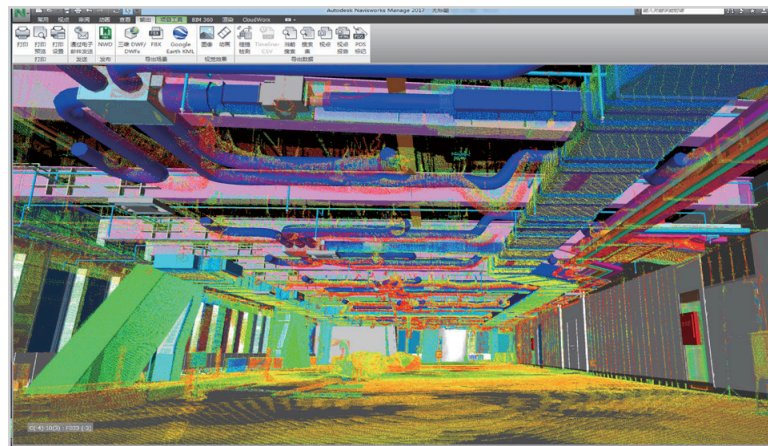
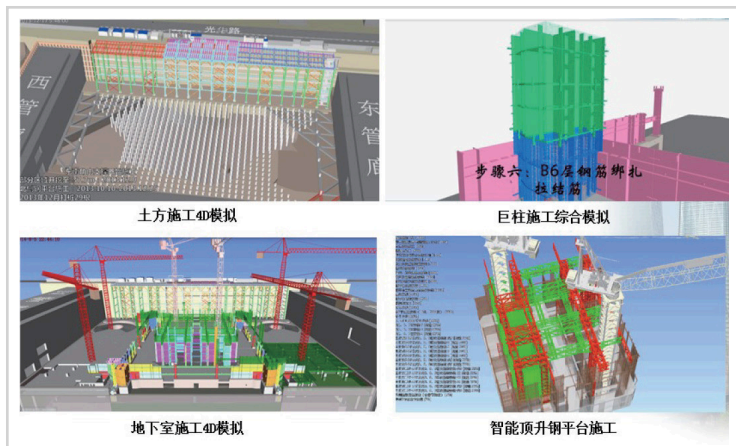
On-site inspection with BIM data presented on iPad simplifies the difficulty of construction management, reduce errors, saves times and improves efficiency

BIM Construction Simulation

BIM teams are fully engaged in the development of all major construction plans. The plans are simulated with Autodesk Navisworks to highlight clashes among space, progress and resources. By doing so, the teams can optimize construction arrangements and processes to ensure smooth execution. For the parts with complex nodes that need cross-functional support, the teams would predefine the nodes in a BIM setting and assist in analysis.

Since the construction started, the team simulated over 10 large-scale plans. The outcome is a bunch of video files covering construction methods, processes, equipment specification including

- design of cross-piping and chute in foundation structure
- large-volume concrete pouring
- installation of mega-columns
- basement composite structure construction
- installation and jacking of special equipment integration platform
- construction steps of frame-core steel plate shear wall
- selection and transportation of large mechanical and electrical equipment
- delivery and installation of curtain wall units
- tower crown installation and tower crane demolition.



It represents an innovative approach to select from plan options and guides construction.

The working schedules is imported into Autodesk Navisworks to develop an animation where actual progress and automatically-generated schedule are shown in different colors for comparison. It gives an intuitive depiction of work progress and key roadmap.

Prefabrication and digital processing

China Zun Tower project actively promotes prefabrication for energy efficiency and green construction. Scale use of prefabricated parts saves energy, cost and space. At the same time, construction quality and speed are greatly improved. It is estimated that construction wastes plunge by 90%, while water and electricity consumed in construction are only 20% of those in conventional projects. Construction is well organized despite the little space available on site for construction.

For example:

- Prefabricated vertical pipeline technology is employed from Floor 7 to Floor 102. 222 sets of prefabricated pipelines that designed and tagged in Autodesk Revit are installed, including air conditioning water system and fire-fighting system. Work load of on-site welding is cut by 30%, plus substantial saving in labor.
- Decoration Team also prefabricate irregularly-shaped parts for fine decoration in lobby and premium offices. The team uses Autodesk Dynamo for complex parts, and import parameters to CNC for processing. The finished parts are assembled in the factory space before being installed on site. This ensures sound progress despite limited space on site and the large number of pipeline and wires to be routed

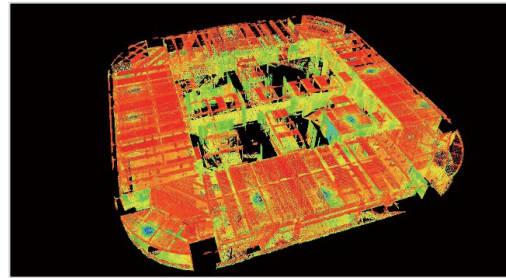
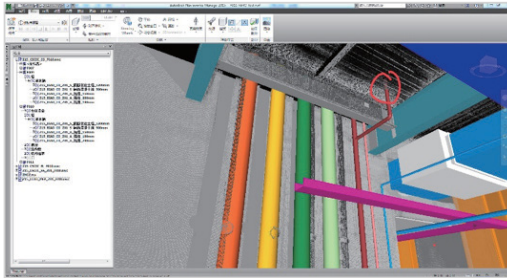
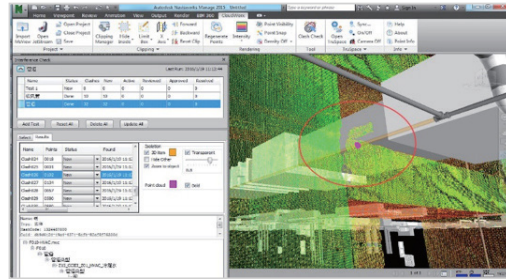
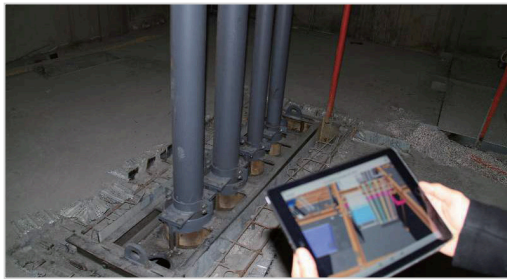
3D scanning data is imported in Autodesk Recap Pro to generate as build BIM models for interior decoration

3D laser scanning

The BIM teams use high-precision 3D laser scanners to scan each floor after its completion. On each floor, there are up to 25 scanning stations, which ensures that scanning results are accurate, comprehensive and blind-spot-free. Data granularity is enhanced to 2mm.

The project generates massive point cloud data. Information and data transmission is a formidable challenge. It is the first time in China that a project uses Jetstream data system, which stores all the data in a central server. Teams get remote access to the data by installing Autodesk Revit or Autodesk Navisworks with plug-ins on client side. This enables full participation in 3D scanning.

3D scanning data keep a reliable record of the construction site. The project quality management team compares the 'real' point cloud data with 'virtual' BIM models and reports on deviation. It helps to identify key components with quality defects and issues, which is critical to make correction in time and improve project quality.



3D scanning data is imported in Autodesk Recap Pro to generate as-built BIM models for interior decoration design and construction guide. It helps the subcontractors to re-optimize their work under the most updated and real conditions, and ensure the completion of project models in as-built status.

It is also an innovative approach to BIM-enabled maintenance. Before construction is completed, mechanical and electrical pipelines in the ceiling and installation in equipment rooms are scanned, to reserve graphic data and location information for operation and maintenance.

Conclusion

The construction team of China Zun Tower is committed to building the world's first super-high skyscraper with life-cycle BIM management. As a key of construction process, BIM application expands and deepens from design phase to construction phase. More importantly, BIM has been integrated in design detailing, on-site management and green construction, empowering full participation and trans-disciplinary coordination. China Zun Tower is a role model of BIM application in mega-size and complex projects and will become a benchmark of BIM in the AEC sector.

About the Company

China State Construction Engineering Corporation Ltd. (CSCEC), one of the world's Top 500 enterprises, is the top-ranking Chinese company on the chart of investment and construction business. As an important subsidiary of CSCEC, the Wuhan-based China Construction Third Engineering Bureau Co., Ltd. (CCTEB) is a leading SOE of construction and installation. Super Project Management Company affiliated to CCTEB offers a professional platform for general contracting and management of highend projects. The company was set up to consolidate competitive strength in high-end construction projects, as well as to promote the management mode of general contracting. According to mandate by the parent company, it mainly engages in general contracting, while expanding presence in PPP and EPC..

