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Author: Weiping Shao, Executive Chief Architect, Beijing Institute of Architectural Design

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China Zun: Shaping the Future Skyline of Beijing

中国尊: 未来北京的城市新高度

Weiping Shao

Weiping Shao

Beijing Institute of Architectural Design
RM.1602. Canway Building, 66 Nanlishi Road
Beijing, China
100045

tel (电话): :+86(10)88021018-6015
fax (传真): :+86(10)88021018-6004
email (电子邮箱): shaoweiping@biad.com.cn
www.biad-ufo.cn

Mr. Shao is the Executive Chief Architect of BIAD, Director of BIAD UFo (Un-Forbidden Office), College Professor, Executive Member and the President of CHINAASC (The Architectural Society of China) and a Senior Advisor to the China Central Government. Representative Works include: Beijing International Airport Terminal 3 (Co-Design with Norman Foster), Sunken Gardens in the Olympic Green, Beijing Phoenix International Media Center, and the New Chinese Embassy in India.

邵韦平现为北京市建筑设计研究院有限公司执行总建筑师兼院方案创作工作室 (UFo) 主任; 中国建筑学会建筑师分会理事长。代表作品有首都机场三号航站楼 (合作)、北京奥林匹克中心区下沉广场、北京凤凰中心、中国驻印度使馆新主楼等。

Abstract

Due to the site location, China Zun has been a high-profile project from the very beginning. The new height of 528m would make the China Zun the new landmark for the historical city of Beijing without any doubt. This paper will present the China Zun project and mainly focus on the architectural design system and criteria. How to categorize the architectural design systems of the overall architectural design principle have been formulated since the early stage of the schematic design. The architectural design systems will be gradually implemented as the project moves forwarded. In addition, applying the Building Information Modeling system has played a necessary role for both the design and construction stages of the China Zun project..

Keywords: China Zun, Super High-Rise, Architectural Design, BIM

摘要

中国尊因地处北京而备受瞩目，528米的高度必将使其成为这座古老城市新的地标。本文着重介绍了中国尊的项目概况，以及其主要建筑系统的设计内容。基于建筑系统划分的整体设计策略在方案之初便被制定，并逐渐在项目推进的过程中得到贯彻落实。此外，日渐成熟的BIM技术为工程的推进提供了必要的技术手段。

关键词: 中国尊、超高层、建筑设计、BIM

Beijing City Historical Background

The city of Beijing has a history of over 3,000 years, and has been the capital of China for more than 800 years. The Forbidden City is located in the center of Beijing with a clear symmetric grid for the city layout. The north-south axis started from the center of the Forbidden City which carried the historical sites of Beijing. The east-west axis is the Chang An Avenue which represented the contemporary urban development of the city. With the Guo Mao Bridge at the East of the 3rd Ring of Beijing as the center of a circle, and with the diameter of 7km range, Beijing Central Business District was on the East extension of the Chang An Avenue. Due to the urban planning regulations and building height restrictions in the historical preservation zone, high-rise towers were restricted in downtown Beijing. Beijing CBD was a breakthrough for shaping the new skyline.

Beijing Central Business District Urbanism and Future Highest Point – China Zun

The construction area in planning of the Beijing Central Business District was about 19,000,000 m^2. The majority of the construction lots in the Beijing CBD around the CBD Core have been completed. The CBD Core area has been preserved for the high-rise towers since 2000

北京城的历史沿革

北京有着三千余年的建城史和八百多年的建都史，紫禁城居中的位置方式奠定了几何方正、轴线明晰的城市格局。南北中轴线承载着北京的历史，紫禁城是历史的起点。与中轴线正交的长安街是一条记录着当代城市发展足迹的东西轴线，北京CBD就位于这条轴线之上，以国贸桥为核心的7平方公里的范围之内。由于城市历史风貌保护的原因，北京的超高层建筑在城市内区被限制，CBD是北京超高层建设的一次历史性突破。

北京CBD核心区都市建设计划与京城未来第一高度——中国尊

北京CBD区域规划建筑总面积近1900万平方米。CBD核心区周边大部分地块的建设工作已接近完成。自2000年以来作为预留用地的核心区，具有举足轻重的作用和后发优势。2010年地方政府决定启动核心区的建设计划，核心区占地约30公顷，规划建筑总面积约410万平方米: 地上建筑面积约270万平方米; 地下建筑面积约140万平方米。

核心区的建设模式是一种开拓性的尝试，在确定了控规条件之后，优先起动的是位于道路和城市开放空间以下的建筑面积52万平方米的城市公共服务基础设施，暨核心区地下公共空间项目，其由政府主导，

which played an important role to re-shape the city with more effective land use policies, to provide improved infrastructures, and to provide the city better public spaces. In 2010, Beijing government re-started the CBD Core project with a site area of 30 ha, and the construction area in planning of 4,100,000 m^2. There would be 2,700,000 m^2 of High-Rise towers above the ground, and 1,400,000 m^2 below the ground.

The construction of the CBD Core was a pioneering attempt of Chinese architecture. After refining the zoning and urban planning regulations, the First-Class development of the public spaces and underground system has broken the ground first. With 520,000 m^2 of the municipal facilities and public infrastructure, the public space and underground system played a multi-function role on integrating the public park with public transportation, decreasing the local traffic, and providing municipal connections to the secondary lots and civil defense facilities as one system. (See Figure 1). The public space and underground system has been separated into layers by different functions. The municipal layer was at B0.5; underground pedestrian layer was at B1 level, the vehicle layer was at B2 level, civil defense and public parking layers at B03-B05. The efficiency of land use was increased by the three-dimensional underground traffic system; the municipal lines were placed into interior maintenance corridor which would be much easier to maintain and to repair.

China Zun would be the tallest building in the CBD which redraw the skyline of the city. (See Figure 2). The inspiration of the building geometry was from the Chinese traditional vase "Zun". The outline of the façade minified as the building goes up. The standard floor plan was square with filet corners. The top floors of the China Zun expended again to provide efficient office space.

China Zun – Project Overview

The project site of China Zun was about 1.15ha with a construction area of 437,000 m^2. There were 350,000 m^2 above the ground, and 87,000 m^2 below the ground. With a building height of 528 m, there were 108 floors above the ground and 7 floors below the ground. There were 10 vertical functional zones in the building providing working space for 20,000 people. It also contained the world's largest high-rise viewing platform on the top floor of the China Zun.

Above the grounds, the tower would mainly use for office areas, conference halls and public visiting route. The conference halls were located above the ground lobby in the double ceiling high mezzanine which could be easily access by the escalator from the main entrance. Each office zone was formed by a MEP floor & refuge floor on the bottom, standard office floors in the middle and executive office floor on the top. In some of the office zone, there were secondary lobbies and staff dining hall floors. On the very top of the tower, there would be a viewing platform with multifunctional center which provided a 360°viewing route around the elevator core with a ceiling high of 15 meters. Public visitors would be able to overlook Beijing with an entire new view. The underground space of the tower was mainly used for the power center, the back of house supplying system, pedestrian circulations and underground parking system.

统筹整合环境、交通、市政、防灾等多种城市功能，为各二级地块提供基础设施的标准接口，同时为市民生活提供高品质的城市公园 (请见图1) 。核心区地下公共空间按功能分层，地下层入口设有市政管廊层、人行交通服务层位于地下一层、机动车交通环廊层位于地下二层、人防设施和机动车库层位于地下三至地下五层。各种交通方式在这里实现立体化解决，提升了城市效率; 绝大部分市政管线进入永久性的公共管廊，提高城市运行效率和安全度，优化了城市资源。

中国尊是核心区中轴线上最重要的建筑，也是CBD区域的制高点，重新定义了城市的天际线 (请见图2) 。塔楼造型灵感来源于中国传统礼器"尊"，具有收腰的身形特点。这种形体下，建筑在较高处楼层的面积适当增大，从而获得宝贵的高空体验。

中国尊之项目概况

中国尊占地面积约1.15公顷; 总建筑面积为43.7万平方米，其中地上35万平方米、地下8.7万平方米; 高度达到528米，地上108层，地下7层。整个塔楼有十个垂直功能分区，为城市提供了近两万人的工作空间以及世界上最高最大的观景平台。

地上部分主要设有办公区、会议区和观光区。会议区设置于首层大堂上方，可由扶梯直接到达。各办公区之底层配置设备层和避难层，上层则为标准办公层以及行政办公层，部分办公区还设有空中大堂、员工餐厅等功能楼层。塔楼最顶端设有观光平台与多功能中心，观光平台呈360度环绕布置于核心筒周边，观光空间高达十五米，人们在这里可以俯看京城。地下部分是整栋大楼的物流和能源中心，同时也是人员及停车之交通枢纽。

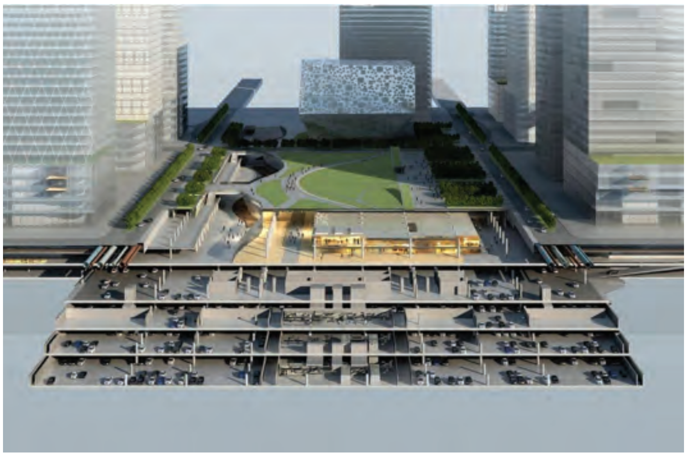

Figure 1. The section drawing of the public underground system of Beijing central business district core (Source: Beijing Institute of Architectural Design)
图1. 北京CBD核心区公共空间剖面 (出自: BIAD)

Figure 2. China Zun rendering image (Source: Kohn Pedersen Fox Associates P.C.)
图2. 中国尊设计效果 (出自: KPF)

China Zun – Overall Design Strategy

China Zun tries to achieve the following architectural qualities: utilizing high operation efficiency, providing advanced and easy access, maximizing the floor usage and maximizing the floor efficiency; minimizing the travel times and walking distance, applying reliable and safe technologies for high operation efficiencies and low maintains costs; providing comfortable working space in human scale and ecological atmosphere; exploiting sustainable design and green energy uses; applying reasonable cost control not only in construction but also in future maintenance and operation.

The main design strategy was to achieve the demands of the architectural qualities. By dividing the design interfaces, the architects were able to coordinate with the engineers as closely as possible. Due to the complexity of the China Zun, there were numerous special engineers and consultants involved and work crossing each other's specialties. Based on this multi-disciplinary, the architects were able to comprehensively evaluate on the architectural geometry, structural system, and functional operation while the construction is under progress.

The main design strategy used specific architectural module and division system to implement design guidance. Specific architectural module was the base unit which guides the engineering design. Then the design system was divided into the frame and ten functional zones. Considering traffic circulation, security, and other requirements, the architectural design had five standard modules. (See Figure 3) Each module had an independent operation and security circulation.

It was a challenge to divide the complex project like China Zun into different divisions and systems. The diversity of the complex system makes China Zun very unique. The architects need to consider spatial and operational characteristics before they decide on the boundary of one division. Each division played a different role in operation, each division also effected on how to group the model parts in BIM.

China Zun – Structural System

The main structural system of the tower was double cylinder. The inner cylinder was made of steel reinforce concrete with I beam instead of regular ray bars. The exterior cylinder was made of steel column frames with giant bracing. The double cylinder structural system generates several structural secondary systems to stabilize the tower.

The elevators cores were extending up from the ground floor level to the top floors which were the vertical circulations going through the entire building. The plan of the cores was almost in square shapes, the shield walls were gradually becoming thinner as it went up. The shield walls were made of reinforces concrete with steel frames. There were horizontal supports alone the elevator cores at the middle section of the tower. The exterior cylinder were made of giant columns, giant beams and bracing, transferring trusses and secondary trusses. The giant columns were located at the corners of the floor plan going all the way up to the top. There were transferring trusses and secondary trusses at each different zone. The planes of the giant column were polygonal contours. The plane decreased as the column went up. The giant side supports were welded into the columns. The transferring trusses were placed alone the vertical functional zones of the tower. There were seven floors below the ground level of the tower with piled raft system which transferred the vertical loading directly into the piled raft foundations. The giant columns and the outline of the elevator cores were supported by buttresses walls. Pile foundation were prouted bored by double side piles.

中国尊之整体设计策略

中国尊的建筑品质目标由以下几方面构成: 运营高效、先进便捷，最大限度的节省空间与时间成本; 技术可靠、保障安全，设置多重安全措施，力求平稳运营; 以人为本、舒适度高，人性化的空间设计，接近大自然的环境设定; 环保节能、绿色可持续，有效控制能耗; 成本合理受控，让建筑在全生命周期各阶段内都能有效地降低相关建设与运营成本。

整体设计策略以建筑品质为诉求，通过精细的工作界面划分、完善的专业计划协调，力求目标的可控实现。中国尊由于工程的特殊性，其所涵盖的建筑内容由众多专项构成，相关的顾问机构就多达几十家，各不同学科之间彼此交互合作。整体设计策略充分考虑了建筑形态、结构体系、保障运行的基础因素，同时将工程进展的时间概念也参考其中，形成一整套多维度持续完善的技术手段。

整体设计策略通过模块理念与系统划分的方式加以具体实施。模块概念是整体设计策略的构成基础，其指导着各系统的设计实施。以建筑的巨框结构和十个功能分区为前提条件，考虑到规模、交通、安防等因素，将建筑划分五个单元模块 (请见图3) 。在设计中首先构建建筑运行的基础性系统，保证每个模块具有相对独立的运行和安全保障条件。

像中国尊这样复杂的项目要细分为不同的部门及系统是很有挑战性的。中国尊所具备的复杂特点体现在其系统构成的多样性。系统划分需考虑到系统要素的空间特点、运行特点等，同时系统应能随着设计的深化进行分解与完善。不同系统对建筑的运行有不同的作用，系统本身有重要与次要之分，系统划分的方式直接影响到建筑信息模型的建立。

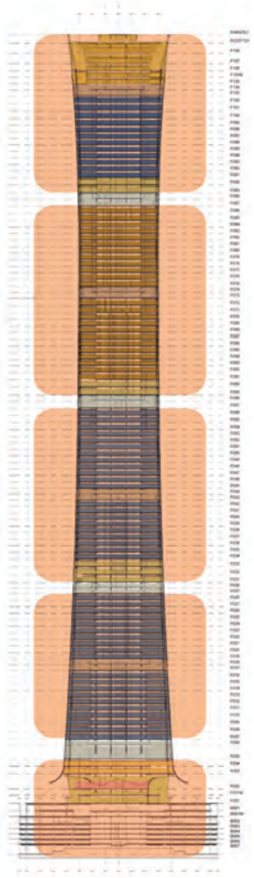

Figure 3. China Zun standard module division (Source: Beijing Institute of Architectural Design)

图3. 中国尊模块划分 (出自: BIAD)

分类category	主系统（一级系统） Main System (Primary System)	二级子系统Secondary System	三级子系统（或构件）Tertiary System (or comportments)	四级子系统（或构件）Quandary System (or comportments)
室外工程Outline Engineering	道路广场系统 Road and plaza System	机动车道路系统 Vehical system		
		汽车库出入口系统 Garage entry exit system		
		广场系统 plaza system		
		人行道系统Pedestrian system		
		人行出入口系统 Pedestrian Underground Entrance/Exists System	建筑入口台阶 Entrance Steps	
			残疾人坡道 Handicapped Ramps	
			散水Drainage skirt	
			人行出口楼梯Stair Entrances/Exists	外围护结构Outline Fence Structure
				外装修 Outline Fitting
		自行车出入口系统Bicycle Entrance/Exists System	外围护结构Outline Fence Structure	
			外装修Outline Fitting	
		道路照明系统 Road lighting system		
	竖向系统 Vertical System			

Figure 4. China Zun architectural system division (Source: Beijing Institute of Architectural Design)
图4. 中国尊建筑系统划分局部 (出自: BIAD)

China Zun – Façade System

The exterior façade was made of glass curtain panels and the metal frames. The frames varied from wide to narrow as the tower went up. The horizontal and the vertical frames did not only emphasis the geometries of the tower, but also smoothly transferred the flat glass panels at the corners which was able to reduce the contrast between lights and shadows. The frames were also able to hide the exhausted openings of the MEP. The glass curtain walls were made of standard units and carried the same design characteristics through the tower.

The standard floor height was 4.5m. The standard glass curtain wall unit was made of glass panels and metal frames. The glass panel was made of low iron glass panels and aluminum alloy frames. The hardwires of the façade were aluminum alloy. And outside surface of the hardwires were stainless steel. The top floor of the observation space used the low iron glass, which would effectively enhance the interior light and landscape. The entrance awning used malleable shell, which carried the shape of the Zun as the skill of the tower. Even though the entrance looked like a complex surface, but it was mainly covered by flat glass panels which was simplifying the fabrication and installation.

China Zun – Elevator System

The passenger elevators would serve for the officers, tourism, conference visitors, catering, and to the parking garage. There were also shuttle lifts and elevators for back of house and other services. The regular officers would use high-speed shuttle elevators with double-decks: the first floor and the ground floor of the building has a dedicated mezzanine waiting hall, district office staff were different elevator reaches the specified upper or lower car; shuttle elevator to the point of way directly to the exclusive air lobby; different partitions office staff and then take it to the floor by the air in the lobby of the area where the partition elevator. Taking into account the special nature of the service and to meet the target to reach diverse needs, VIP shuttle elevator stops at all the conditions of the floor with a lift gate, and normal operation only when the executive floor districts docked.

中国尊之结构体系

塔楼为筒中筒结构，内部为型钢混凝土核心筒，外筒由巨型支撑和巨型框架以及次框架组成。内外筒共同构成多道设防的结构体系以稳定塔楼。

核心筒从承台面向上延伸至大厦顶层，贯穿建筑物全高。核心筒平面基本呈正方形，周边墙体厚度由下至上逐步变薄，采用内含钢骨的型钢混凝土剪力墙结构。在塔楼腰部区域核心筒周边墙肢内均匀布置了水平的型钢暗撑。外筒由巨型柱、巨型支撑、转换桁架以及次框架组成。巨型柱位于建筑物平面四角并贯通至结构顶部，在各区段分别与转换桁架、巨型支撑连接。巨型柱平面轮廓为多边形，沿建筑高度向上尺寸逐渐缩小。巨型支撑采用焊接箱型截面，与巨型柱连接。转换桁架沿塔楼竖向建筑功能节间布置。主塔楼有七层地下室，塔楼采用桩筏基础，所有主要结构将从上部伸延至地下室，并支承于筏板。巨柱和核心筒外侧在底部设置翼墙，以使荷载分布更平均。桩基础为采用桩侧、桩端复式注浆的钻孔灌注桩。

中国尊之幕墙表皮

塔楼外幕墙由玻璃面和宽度渐变的竖向金属装饰条构成，装饰条随着楼层往上会由宽变窄，此渐变的竖向肌理不但强调了塔楼的形体特征，也弱化塔楼立面在转角处转折产生的光影反差，并且对机电设备的排风开口做了一定的遮蔽。外幕墙的主体墙型为单元式构造，其几何分格上下连贯。

塔楼标准层高4.5米，标准幕墙单元主要由玻璃单元和金属单元组合而成。玻璃单元使用双中空Low-E玻璃和铝合金型材结构框，玻璃外层为超白夹胶玻璃，内层为清玻璃。金属单元主要构件为铝合金型材，外包是带有压花纹理的不锈钢板。塔楼顶部观光台的玻璃幕墙为全超白，可以有效增强室内光线和景观融入，以提高空间品质。入口雨篷处理沿用了尊的造形技巧，把塔楼的主体幕墙处理成一个可延展的壳体，在入口做拉起和延伸。虽然入口造型整体为复杂曲面，在弯曲大的部分玻璃之间做了平板分层的鳞片式处理，大大简化了玻璃的制作和安装难度。

中国尊之电梯系统

中国尊的客用电梯服务于办公、观光、会议、餐饮、车库等功能，分为穿梭电梯和区间电梯，分别负责区间人员运送和区内人

Logistics elevator tower uses the same full-height lift stroke design strategy combines with elevators, elevator part of the whole trip as a high fire elevator. Back to their respective local service elevators, elevators back the same position in a plane vertical to share the same shaft, is connected to its corresponding floor building standard office equipment level, the area is mainly used for transporting goods. The building also features a large freight elevator to meet the requirements of large transport critical equipment.

员运送。供一般办公人员使用的穿梭电梯为高速双层轿厢电梯:在大楼首层和地下一夹层设有专用等候大厅，不同分区办公人员分别到达指定电梯的上层或下层轿厢;穿梭电梯以点对点的方式直接到达专属空中大堂;不同分区办公人员再由空中大堂转乘其所前往楼层所在分区的区间电梯。考虑到服务对象的特殊性及满足多样的到达需求，贵宾穿梭电梯在所有具备停靠条件的楼层均设有电梯门，而常态运行时仅在各区的行政楼层停靠。

后勤电梯同样采用塔楼全高行程电梯与区间电梯相结合的设计策略，部分全高行程电梯也作为消防电梯。后勤区间电梯为各自区内服务，位于平面中相同位置的后勤区间电梯上下共用相同井道，连接大楼标准办公层与其相应的设备层，主要用作区内物资的运送。大楼同时设有一部超大货梯，以满足大型重要设备的运送要求。

China Zun – Fire Safety System

The fire safety design of the China Zun respected the following principles: it was categorized into different zone by different functional requirements with a self-contained fire system; the fire escape loading was strictly controlled; applying Class A non-combustible materials for interior design and furniture; the fire trucks were able to reach up to 100 meter high region; helicopter rescue was provided for emergencies.

Due to the Chinese Fire Safety codes and Beijing Local Building Code requirements, fire performance design was applied. Therefore, In the event of a fire, people were able to escape to the upper and lower floors of three-story evacuation; when the fire spread to other floors, people would evacuate for the entire zone. When the fire was out of control, the entire tower would need to evacuate. In addition, the shuttle lifts could use as auxiliary evacuation. In various fire scenarios for evacuation shuttle elevator down to the first floor first, followed by the professionals to operate, on to the relevant secondary evacuation refuge floors. For assisted evacuation purposes shuttle elevator with reliable backup power.

中国尊之消防设计

中国尊的消防设计立足于自救，具体依循以下原则:根据功能分区实施分区保护措施，使消防系统可以在一个区段或一个模块内自成体系;严格控制各逃生通道的火灾负荷，通常采用A级不燃材料;室外场地设置满足100米登高消防车的救援要求;屋顶可满足直升机空中救援要求。

中国尊的消防性能化设计遵循中国消防法规及北京市大楼管理规范，按照火灾等级分区疏散的策略。在火灾发生时，其所在楼层及其上下两层共三层楼人员疏散;当火灾蔓延到其他楼层时，疏散着火楼层所在区段全区人员;当火灾持续时间过长，无法控制时，开始全楼疏散。此外，穿梭电梯也用作辅助疏散。在各种火灾场景下，用于疏散的穿梭电梯首先降至首层，之后由专业人员操作，上至相关的避难层辅助疏散。作辅助疏散用途的穿梭电梯配备可靠的备用电源。

China Zun – Bim System

The implementation of the BIM system has provided the China Zun a highly efficient design approach. Using the architectural model as the fundamental base, all engineers and the consultants apply 3D collaborative design.

Official publications on BIM standards were helpful to set up the design collaboration between different design teams and specialists. It provided clear standards for both hardware and software platforms. It also provided strict control on design staff managements and security of the design files. It unified the 2D drawings which were able to ensure the architectural system corresponds to the modeling system completely. And the BIM standards were constantly upgrading while the project was in progress.

From the geometric control system to the mechanical and electrical systems, BIM played a very important role. The 3D visualization features provided a good validation system for all the engineering designs. Especially in certain critical areas and design conditions, the architects and the engineers were able to maximize the usage of the space. (See Figure 5) BIM system would continue to be in use for the full application lifecycle of China Zun that the database of design and construction and would support the future operation and maintenance.

During the design process of the China Zun, BIM model was not only for spatial studies or engineering statistics, but also used as an overall database of the entire building which was able to record all features. The BIM model of the China Zun conducted its database into four contents: collecting and collating the existing information into the database; recording and collating the indirectly convert information;

中国尊之BIM应用

BIM的实施，为中国尊提供了高效的设计方式，BIM工作的开展以实现项目全虚拟建造为目标。中国尊以唯一建筑信息模型为基础，在建筑专业的主导下进行全专业多学科集成的三维协同设计。

BIM平台的建构及标准文件的发布使项目的设计实施有章可循。针对项目多系统多参与团队的特点，硬件设施及软件平台需顾及到安全与开放的要求，同时对人员组织架构及文件管理实施严密的控制。二维图面对建筑各系统进行了完备的限定，使模型与建筑系统实现完全对应。标准文件会随着项目的实施进行相应的升级完善。

从几何控制系统到地库机电系统，BIM都发挥了至关重要的作用。其三维可视化的特点，为工程的技术设计提供了良好的校验平台，尤其是在某些极限设计条件下，空间利用被发挥到极致(请见图6)。项目力图实现BIM的全生命周期应用，使设计、建造、运营不同阶段所需的信息进行完整有效的传递，并能支持未来相关数据库的开发。

在中国尊的设计过程中，BIM模型已不仅作为空间研究或工程量统计之用，其本身所具备的信息特征被充分挖掘加以拓展，以实现项目的全信息记录。中国尊结合模型中的基础数据信息，进行了相关数据库的研发，具体包含以下四项内容:对模型已有信息进行采集和整理;对模型不能直接记录的信息进行记录和整理;对以上两部分信息进行整合，形成项目的全信息平台;开发数据接

after integrating and processing the previous two sets of information, it formed an information platform for the entire project; developing data interfaces for professional testing and simulation for subsequent phases, and then providing comprehensive information for future adjustments. The database of the China Zun was completing and application of the database was upon the future discussion.

Conclusion

As the construction of the China Zun project has been started, throughout the entire design process, the category the architectural design system has been extremely helpful to the architect and the engineers. In addition, the architects were able to precisely control the project from designing to modeling and later to construction into an unprecedented level by using the BIM system, which was able to maximally ensure the overall quality of the project.

口，为相关专业测试与模拟、为后续阶段调整相关信息提供全面详实的资料。中国尊的数据库正在完成中，具体的应用也在进行深入的探讨中。

结语

中国尊项目的建设已全面展开。纵观整个设计流程，基于建筑系统划分的整体设计策略使设计工作受益匪浅。同时，借助于BIM手段，建筑师得以在一个前所未有的层面上对建筑进行掌控，最大限度地保证了建筑的设计质量。

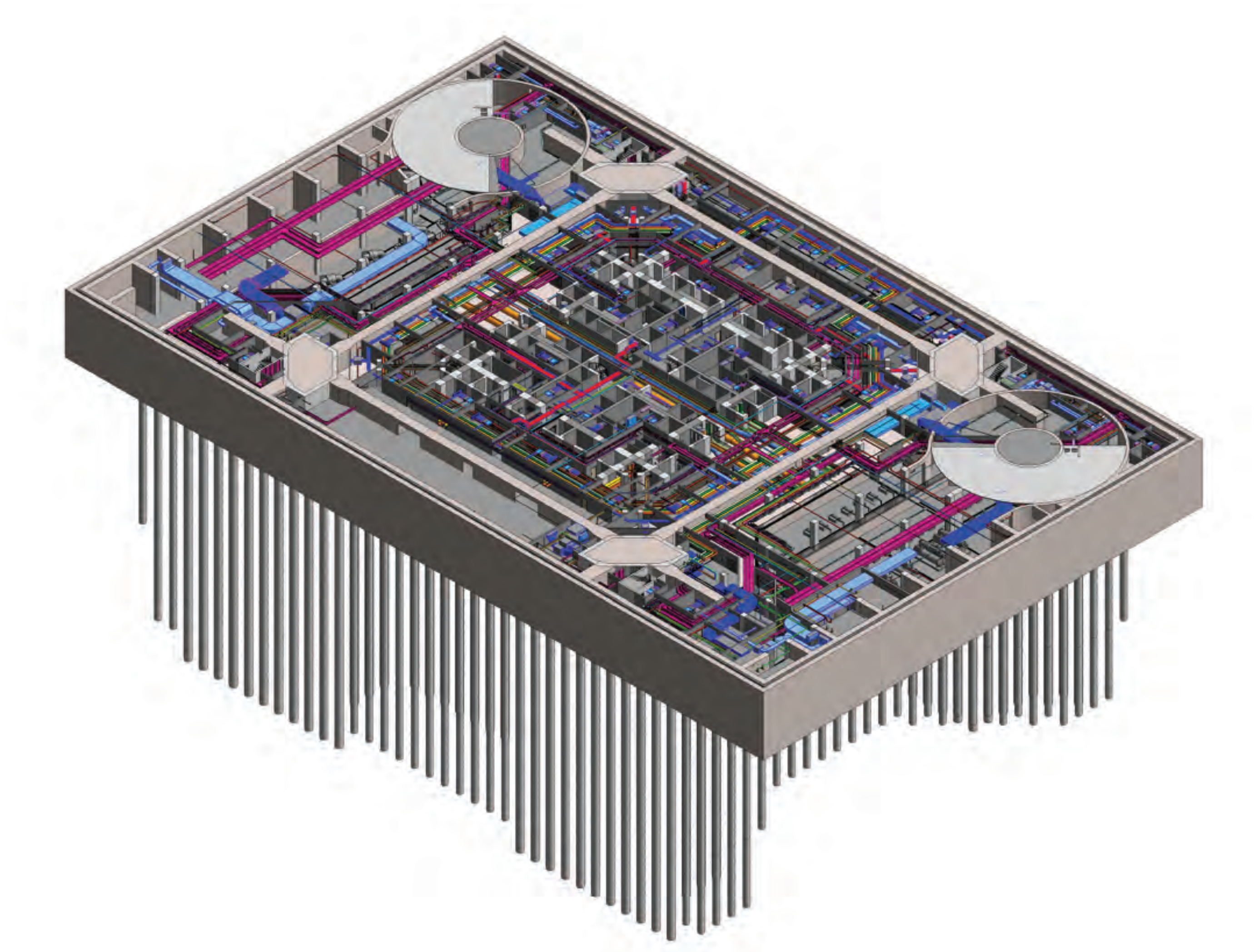

Figure 5. China Zun MEP technicial room study (Source: Beijing Institute of Architectural Design)
图5. 中国尊地库层机电综合空间研究 (出自: BIAD)