Comprehensive Construction Technology for Super High-rise Buildings of Wuhan Greenland Center Project

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1. Project Overview and Progress

工程概况及进展
The general contracting project of A01 super high-rise building project in Wuhan Greenland Center is located in Wuchang Binjiang Business District, Wuhan City, adjacent to the Yangtze River in the west. The total building area of the project is 728,600m². The project is composed of main building, office auxiliary building, SOHO auxiliary building and commercial podium building. The main building has 6 underground floors and 125 aboveground floors with a total building height of 636 meters, which is a super high-rise urban complex integrating super five-star hotel, international Grade A office building, high-end commercial area, top-level apartment, etc. and will become a landmark building in Wuhan and even in Central China after completion.
1.2 Project Current Situation

工程现状

The Tower (350m/636m)

OFFICE (170m, capped)

SOHO

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Yangtze River
2. Project Overall Planning
2.1 Total Plane Management
总平面管理

Contents:

🌟 Enclosing wall, gate
封闭围墙、大门

🌟 Exit passageway
安全通道

🌟 Enterprise CI
企业CI

🌟 Temporary road;
临时道路
Contents:

Temporary water, electric pipe network and power facilities
临水、电管网及动力设施；
Material processing and storage yard
材料加工及堆场
Model display (experience) area
样板展示（体验）区
Large mechanical equipment
大型机械设备
2.2 Vertical Operation Plane Management

竖向作业面管理

Importance(重要性):

The vertical construction subareas of the super high-rise building project are synthetically considered on the basis of operation plane, construction period and cost.

The single-floor building area of the super high-rise building project is generally small, namely, the single-floor operation plane is limited. In order to accelerate the construction progress, the expansion of the vertical operation plane becomes inevitable under the condition that the transverse operation plane is limited.

超高层工程施工的竖向分区是基于作业面、工期和成本的综合考虑。超高层工程的单层建筑面积普遍较小，即单层作业面有限。为了加快施工进度，在横向作业面受局限的情况下，竖向的作业面扩展就成了必然。
2.2 Vertical Operation Plane Management
竖向作业面管理

Methods (方法)：

（1）Separate construction of inner tube and outer frame（内筒外框分开施工）

The height nodes of the super high-rise building project play a vital role in the contract compliance. Based on the separate construction of inner tube and outer frame, the core tube can rapidly “grow tall” through the micro-convex support point backform technology.

超高层工程的高度节点在合同履约里有着至关重要的作用。基于内筒外框的分开施工，核心筒可以借助微凸支点顶模技术迅速“长高”。
Methods (方法):

(2) Flow Construction Organization

流水施工组织

① “Large flow construction”

Considering that the single-floor building area of the main tower in the project is about 3500㎡, the single-floor operation plane is less than 2000㎡ except for various holes, which is really limited. Therefore, multi-specialty becomes inevitable in the vertical spread flow operation.

① “大流水”

考虑到项目主塔楼单层建筑面积3500㎡左右，除去各种洞口，单层作业面不足2000㎡，实在有限，多专业在竖向铺开流水作业就成了必然。
Methods (方法)：

(2) Flow Construction Organization

流水施工组织

② “Small flow construction”

In each technology link, carry out the labor force arrangement through the reasonable subareas and subsections so as to improve the construction efficiency. For instance, in the backform construction link, there are 3 horizontal sections and 4 vertical construction layers for spread operation.

② “小流水”

在各个工艺环节，通过合理的分区分段进行劳动力安排，提高施工效率。例如在顶模施工环节，水平分为3个区段，竖向分4个施工层铺开作业。
3. Vertical Lifelines
3.1 Vertical Flow Construction Organization
垂直流水施工组织

Each specialty is divided into multiple operation planes in the vertical direction according to the reasonable interval, and the uppermost operation plane is used for the core tube construction. At present, the construction progress of the core tube is about 20 floors more than that of the outer frame steel structure. The construction progress difference between the outer frame steel structure and the outer frame floorslab is about 5 floors, and the construction progress difference between the outer frame giant column and the curtain wall is 10-15 floors.

各专业在竖向按合理间距分为多个作业面，最上方为核心筒施工，目前核心筒领先外框钢结构约20层；外框钢结生与外框楼板相差5层左右，外框巨柱与幕墙相差10-15层。
3.2 Vertical Lifelines

3.2.1 Difficulties

- Large-demand and miscellaneous vertical transportation
  垂直运输需求大、繁杂
- Large concrete pumping height (highest: 586m)
  混凝土泵送高度大（最高586m）
- Large hoisting construction height (636m)
  吊装施工高度大（636m）

Steel structure hoisting
钢结构吊装
3.2.2 Vertical Transportation – Tower Crane

After the pouring of the main building massive baseplate is completed, install 7#M1280D luffing tower crane. When the core tube construction reaches 1MF floor, install the jacking formwork system, convert M1280D to internal climbing type, and install 8#M1280D and 9#ZSL2700 internal climbing tower cranes and ZSL380 tower crane on the backform.

主楼大底板浇筑完成后，安装7#M1280D动臂塔吊，核心筒施工至1MF层，安装顶升模架体系，完成后M1280D转为内爬式，安装8#M1280D和9#ZSL2700内爬式塔吊和顶模上ZSL380塔吊。
After the core tube construction reaches 66F, convert 8#M1280D and 9#ZSL2700 tower cranes to external hanging type due to structural change.

核心筒施工到66层后，由于结构的变化，8#M1280D和9#ZSL2700塔吊变为外挂形式。
3.2.2 Vertical Transportation– Tower Crane

When the core tube construction reaches 87F, continue to adduct the tube structure, respectively replace M1280D and ZSL2700 tower cranes with ZSL750 and ZSL380 tower cranes so that three tower cranes continue to climb up.

核心筒施工至87层时，筒体结构继续内收，拆除M1280D和ZSL2700塔吊，分别替换为ZSL750和ZSL380，3台塔吊继续爬升。
3.2.2 Vertical Transportation – Tower Crane

After the core tube concrete structure construction of the main building is completed, use ZSL750 to dismantle M1280D, install the top steel structure, use ZSL380 to dismantle ZSL750, use two roof cranes (ZSL200 and ZSL60) to carry out dismantlement by levels according to the sequence from small to large, and finally dismantle ZSL60 manually.

主楼核心筒混凝土结构施工完成，用ZSL750将M1280D拆除后，进行顶部钢结构安装，完成后用ZSL380拆除ZSL750，使用两台屋面吊ZSL200、ZSL60，按照以小拆大的顺序分级拆卸，最后人工拆除ZSL60。
3.2.3  Vertical Transportation—Construction Elevator
垂直运输—施工电梯

Successively set up 10 construction elevators, set up No.1-No.7 elevators in the core tube by sections, attach No.8-No.10 elevators to the outside of 1-96 floors of the building. No.10 elevator is the single-tower multi-cage circulating elevator independently researched and developed by China Construction Third Engineering Bureau, and the micro-curve design adapting to the architectural appearance has been made.

先后设置10台施工电梯，其中1至7号分段设置在核心筒，8至10号电梯外附于建筑物1-96层，10号电梯为局自主研发的单塔多笼循环电梯，并作出适应建筑物外形的微曲线设计。
Due to the curve surface design of architectural appearance, the attachment distance of the elevator above 70F is more than 3.1m, and it is planned to set up the cantilevered steel frame on the structure floorslab to facilitate the elevator attachment and the erection of access way.

由于建筑外形的曲面设计，70层后电梯附着距离大于3.1米，拟从结构楼板设置外挑式钢架供电梯附着及进出通道的搭设。
When the core tube construction reaches 1MF floor, install No.1 elevator through to the backform platform. When the core tube construction reaches 90F, carry out the foundation conversion of No.1 elevator at 67F position, and then dismantle No.1 elevator part below 67F.

In the middle and later stages of the project, start using 11 permanent elevators as the construction elevators.

在工程中后期启用11部永久电梯作为施工电梯使用。
3.2.4 Vertical Transportation—Concrete Pumping

The highest concrete structure of the main tower body is about 586 meters, which is divided into three sections and provided with three superhigh pressure concrete pumps and three sets of pump pipes. In order to ensure “one pump to top”, three buffer S-shaped elbow pipes are arranged respectively in 25F-27F, 51F-53F and 82F-85F.

塔楼主体混凝土结构最高约586米，分为3个区段配备3台超高压混凝土输送泵、3套泵管；为保证“一泵到顶”，在25至27层、51至53层、82至85层设置三处缓冲S弯头。
3.2.4  Vertical Transportation—Concrete Pumping

During the construction of the core tube concrete backform, adopt three HG20G-3R material distributing machines fixed on the backform truss to cooperate with concrete pouring, which can be jacked up together with the steel platform and rotate by 360° with a rotation radius of 20m. The discharge port is connected with the tumbling barrel for concrete pouring.

核心筒混凝土顶模施工期间采用3台HG20G-3R布料机固定于顶模桁架上配合混凝土浇筑，并与钢平台一起顶升，能360°回转，回转半径为20m，出料口接串简进行混凝土浇筑。
During the outer frame construction, the removable material distributing machine is adopted for pouring, and concrete is connected with the material distributing machine through the vertical transmission pipeline. During pouring, the material distributing machine is moved to ensure that the pouring range of the material distributing machine can cover the whole construction plane.

外框施工采用可移动布料机进行浇筑，混凝土经竖直输送管道连接布料机，浇筑时对布料机进行移动，确保布料机浇筑范围可覆盖整个施工面。
4. Important and Difficult Points and Key Technologies of Construction
4.1 Riverside Ultra-large and Ultra-deep Foundation Pit

The foundation pit project has a length of about 304m, a width of about 121m and an area of about 36,000m², and a deep foundation pit construction method of reducing underground space deformation is put forward. Namely, the foundation pit is divided into three areas along the length direction. The two-side areas of the foundation pit shall be first constructed, and the earth excavation of its middle area shall be started after the basement is capped.

基坑工程长约304m，宽约121m，面积约为3.6万㎡，提出了一种减少地下空间变形的深基坑施工方法。即将基坑沿长度方向分为3个区，先施工两侧区域，待地下室封顶后再开始中间区域的土方开挖。
4.1.1 Engineering Pile Construction

工程桩施工

The engineering pile verticality shall reach 1/250 far less than 1/100 required in national standards, and the slightly weathered rock exceeds 1.2m.

工程桩垂直度要求达到1/250，远超过国标要求的1/100，入微风化岩超过1.2m。

The two types of drilling rigs are adopted to cooperatively drill holes. The rotary drilling rig works in the sand soil layer, and the percussion reverse-circulation drilling rig works in the rock layer. The quantity configuration is 1:4, and the advantages of these two types of equipment are well utilized to improve the construction efficiency.

采用两种钻机配合成孔，旋挖钻机工作于砂土层，冲击反循环钻机工作于岩层，数量采用1:4配置，很好地利用了这两种设备的优势，施工效率高。
4.1.2 Underground Diaphragm Wall Construction

(2) The requirements for underground diaphragm wall verticality are high, and the moderately weathered rock exceeds 1.5m. The deepest place reaches 56.9m, and the heaviest single reinforcement cage is 85.6t. Through overall processing and hoisting technology, reinforcement cages are one-time hoisted into troughs by 300t and 150t machines.

(2) 地下连续墙垂直度要求高、入中风化岩超过1.5m; 最深达56.9m，钢筋笼单幅最重85.6t，钢筋笼吊装采用整体加工、吊装工艺，利用300t和150t双机一次性吊装入槽。

Grab-bucket trenching machine
抓斗式成槽机

Geotechnical H-8 slot milling machine
土力H-8铣槽机

Double-machine integral hoisting
双机整体吊装
4.1.3 Earthwork and Support Construction

(3) Due to large earthwork volume and long construction period, two flood seasons need to be undergone.

(3) 土方量大且工期长，需经历2个汛期

Through the optimization of trestle bridge design, reasonably match the unearthed equipment and scheme to ensure the high efficiency and safety of earthwork and support construction.

通过优化栈桥设计，合理搭配出土设备及方案，保证土方及支撑施工的高效、安全。
4.1.4 Brace Blasting Construction
支撑爆破施工

(4) Internal brace blasting green construction
(4) 内支撑爆破绿色施工

Through the implementation of spraying and watering, protective belt, steel plate coverage and other measures, avoid noise, smoke dust, gravel splashing, etc. Purchase the brick making machine to reuse the blasted concrete slag.

通过喷淋洒水、防护带和钢板覆盖等多项措施的实施，避免噪声、烟尘、碎石飞溅等；购置制砖机将爆破砼渣进行重复利用。
4.2 Mass Concrete Baseplate

The concrete thickness of deep pit baseplate of the tower middle area 1 is 5m, and the foundation baseplate area within the scope of pouring belt after settlement is 6,304m². The concrete has a grade of C50, a seepage resistance grade of P10 and a total one-time pouring amount of about 31,000m² and therefore belongs to mass concrete.

塔楼中间1区深坑底板混凝土厚度5m，沉降后浇带范围内基础底板面积为6304㎡，混凝土等级为C50，抗渗等级为P10，一次性浇筑总量近3.1万m³，属于大体积混凝土。
4.2.1 Waterproof Construction

The project adopts the construction technology of polymer self-adhesive membrane waterproof roll materials with pre-installed and inverted adhered method to realize the persistent and close full adhesion of roll materials and concrete through the special function of adhesive layer and surface particle layer so as to achieve the “skin-type waterproofing”.

项目采用高分子自粘胶膜防水卷材预铺反粘技术，通过胶粘层与表面颗粒层的特殊作用，可实现卷材与混凝土持久紧密的满粘，做到“皮肤式防水”。

Comparison of process and construction period
工序及工期对比

Water-collecting well laying and cushion cap treatment
集水井铺设及承台处理
4.2.2 Reinforcement Construction
钢筋施工

The maximum diameter of baseplate reinforcement is 50mm, and the reinforcement binding difficulty is large due to complex pit-in-pit.

底板钢筋最大直径50mm，坑中坑复杂，钢筋绑扎难度大。

Through BIM technology, carry out the reinforcement configuration and simulation, guide the processing and binding, and customize Φ50mm reinforcement in advance. Design the reinforcement steel support system to support temperature reinforcement and top reinforcement, and simultaneously provide the operation plane.

通过BIM技术进行钢筋排布模拟，指导加工、绑扎，并提前定制50钢筋。设计型钢支撑体系为温度筋、面筋做支撑，同时提供作业面。
4.2.3 Prevention and Treatment of Construction Cold Joints
施工冷缝防治

Reasonably plan the transportation route to ensure that the concrete supply meets the on-site demand. Cooperate the chute with the ground pump for pouring to ensure that on-site pouring strength meets the requirements. Ensure the quality and strength of vibration.

合理规划交通路线，保证混凝土供应量满足现场需求；采用溜槽配合地泵来进行浇注，保证现场的浇注强度满足需求；保证振捣的质量与强度。

Organization of tank trucks
罐车组织

Chute construction
溜槽施工

Concrete vibration
混凝土振捣
4.2.4 Temperature Cracking Control

温度裂缝控制

Through the test, adjust the mixing proportion, add an appropriate amount of admixture, and reduce the hydration heat. Carry out the dynamic real-time monitoring through the wireless temperature measuring method so as to timely take corresponding measures.

通过试验调整配合比，掺入适量外加剂，降低水化热；采用无线测温的方法进行动态实时监控，以及时采取相应措施。
4.3 SRC Core Tube—Backform Technology
钢骨混凝土核心筒--顶模工艺

4.3.1 Requirements of Core Tube Construction for Formwork System
核心筒施工对模架系统的需求

(1) Due to the special structure form (triangle) and insufficient hoisting capacity (only provided with three luffing tower cranes), the formwork system shall be integrated with the tower crane to enhance the hoisting capacity.

(1) 由于结构形式特殊，呈三角形，仅配备三台动臂式塔吊，吊运能力不足，需在模架体系集成塔吊，增强吊运能力。

ZSL380 luffing tower crane on backform
顶模上ZSL380动臂塔吊

Tower crane foundation connection
塔吊基础连接
4.3.1 Requirements of Core Tube Construction for Formwork System

(2) Due to a larger plane structure change, the support frames of the three tower cranes occupy a large amount of space in the tube, and the selection of support points of the traditional jacking formwork is inconvenient. The project selects a total of 12 support points in three sections. The jacking force of six cylinders in the inner side is 350t, and the jacking force of six cylinders in the outer side is 300t.

(2) 平面结构变化较大，三台塔吊的支撑架占用了筒内大量的空间，传统顶升模架的支撑点选取不方便。项目在3个区段共选取12个支点，其中内侧6个油缸顶升力350t，外侧6个油缸顶升力300t。
4.3.1 Requirements of Core Tube Construction for Formwork System

核心筒施工对模架系统的需求

(3) The tower crane is integrated on the platform, and the requirements of the platform on the construction elevator for the lateral resistance performance of the backform are high. The lateral resistance device arranged for the backform transfer upright column effectively resists the wobble of the platform under the action of horizontal load or overturning moment so as to ensure the normal operation of the tower crane on the construction platform.

（3）塔吊集成在平台上，且施工电梯上平台，对顶模的抗侧性能要求高。顶模转接立柱设置的抗侧装置有效的抵抗了平台在水平荷载或者倾覆力矩作用下的晃动，可以保证塔吊在施工平台上的正常运转。
4.3.1 Requirements of Core Tube Construction for Formwork System

核心筒施工对模架系统的需求

(4) The material distributing machine is located at the platform edge, and the tower crane is integrated on the backform. The bearing capacity of the climbing formwork, backform and other traditional formwork systems is difficult to meet the requirements.

(4) 布料机位于平台边部、塔吊集成与顶模之上。爬模、顶模等传统模架体系的承载能力难以满足要求。

Based on the analysis on the above 4 points, select a convex point backform with high bearing capacity, strong adaptability and support points located at the core tube outer wall as the formwork system of the core tube construction, and innovatively integrate the large-scale tower crane on the platform.

基于上述4点分析，选择一种承载力高、适应性强，支撑点位于核心筒外侧墙体的凸点顶模作为核心筒施工的模架体系，并创新将大型塔机集成于平台上。
4.3.2 Backform Design Overview

The backform of Wuhan Greenland Center is mainly composed of steel frame system, support and jacking system, formwork system, hanger system, ancillary facilities system and ZSL380 luffing tower crane, which is supported on the core tube outer wall and has an overall weight of about 2000t. The plane area of the platform is about 1655m², and its top is provided with a reinforcement storage yard with an area of 500m².

武汉绿地中心顶模主要由钢框架系统、支撑与顶升系统、模板系统、挂架系统、附属设施系统以及一台ZSL380动臂塔吊组成，支撑在核心筒外围墙体上，整体重约2000吨。平台平面面积约1655平米，其顶部设置钢筋堆场约500平米。
The overall height of the platform is about 35m, which is provided with four construction layers (including steel structure hoisting layer, reinforcement binding layer, concrete pouring layer and hole embedded parts treatment layer).

平台的整体高度约35m，设计有4个施工层（钢结构吊装层、钢筋绑扎层、混凝土浇筑层、洞口埋件处理层）。

The formwork system is the aluminum formwork used for the vertical concrete wall construction, which is hung on the steel platform and synchronously lifted with the jacking formwork.

模板系统采用铝模板，用于竖向混凝土墙体施工，悬挂在钢平台上，随顶升模架同步提升。
Thank you!