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FINE CONTROL TECHNOLOGY FOR CONSTRUCTION ORGANIZATION OF SUPER-LARGE UNDERGROUND SPACE ADJACENT TO SUBWAY

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Abstract: This study proposes a series of innovative construction deployment and technical strategies for the large-scale deep foundation pit project adjacent to the subway in the Hangzhou Convention and Exhibition Project. The study focuses on how to efficiently promote the development of underground space while ensuring the safety and stable operation of subway facilities. Through a detailed analysis of the project profile and challenges faced, this study proposes a bilaterally symmetrical large-division overall deployment strategy of non-reserved area → ground protection area → reserved area → central corridor, as well as a construction deployment plan of exhibition hall area pipe piles → ground protection area cast-in-place piles → reserved area cast-in-place piles. In addition, the refined construction deployment of large-division small-block skipping combined with ultra-large temperature post-casting strips was adopted to effectively solve the technical difficulties in construction. The results show that these strategies improve construction efficiency, ensure the safety of subway operation, and provide feasible technical solutions for similar projects.
Keywords: Underground space; Deep foundation pit project; Subway protection; Construction deployment

1 INTRODUCTION

The accelerated urbanization process is accompanied by increasing risks and challenges [1-2]. The national "14th Five-Year Plan" clearly puts forward the goal of building a "resilient city", emphasizing that cities should have the ability to cope with various risks. The development and utilization of underground space is regarded as a key measure to enhance urban resilience [3-5]. It is expected that the development of underground space will develop in a deeper, wider and more three-dimensional direction in the future [6]. However, this also brings challenges, especially in the context of dense urban rail transit networks. Deep foundation pit projects are close to subway shield tunnels. Improper construction may threaten the safety and operation of subway facilities. Therefore, how to develop underground space efficiently and reasonably while ensuring the safety of subways has become an important topic in urban planning and construction. This study focuses on large-scale deep foundation pit projects close to subways. Through specific case analysis, it explores construction deployment and strategies, aiming to provide technical solutions for similar projects, ensuring the development of underground space while ensuring the safety and stable operation of subway facilities.

2 PROJECT OVERVIEW

The Hangzhou Convention and Exhibition Project is located in Nanyang Street, Xiaoshan. The central part of the site passes under the already operational subway line 1 shield tunnel, and the Zhemei Road Tunnel is planned on the west side of the red line. The project has an underground building area of about 220,000 m2. It is divided into two areas, north and south, with the shield tunnel of Metro Line 1 as the boundary. There are three connecting passages above the tunnel. The foundation pit of the south area is 535.2 m long and 234.2 m wide; the foundation pit of the north area is 510.4 m long and 239.9 m wide. The horizontal distance between the outer wall of the basement on the south side and the tunnel is 6.5~15.9 m, and 22.0 m in some places; the distance on the north side is 9.5~11.7 m, and 30.3~46.8 m in some places. Geological surveys show that the area affected by the foundation pit is mainly a sandy silt layer with good permeability of about 31 m thick, and the groundwater is mainly shallow phreatic type.
The main challenges faced by the project include: (1) Large-scale construction work in the ultra-large underground space adjacent to the subway will cause superimposed disturbance to the central tunnel. (2) The ultra-large-scale pile group construction adjacent to the subway tunnel may have a significant soil squeezing effect on the surrounding area. (3) The ultra-large area of the bottom plate is prone to cracks and leakage. In response to the above problems, this study will systematically analyze and propose solutions.

3 OVERALL CONSTRUCTION DEPLOYMENT TECHNOLOGY FOR THE ULTRA-LARGE UNDERGROUND SPACE ADJACENT TO THE SUBWAY

The project includes 8 exhibition halls and 1 central corridor, and the middle of the site is an already operating double-line subway tunnel. After feasibility analysis, the overall construction deployment strategy of non-reserved area

→ ground protection area → reserved area → central corridor is adopted for large symmetrical partitions on both sides. The reserved area is designed as a temporary road, and the foundation pit in the non-reserved area and the cast-in-place piles in the ground protection area are constructed simultaneously to ensure that they do not interfere with each other, while taking into account the construction progress of the ultra-long and ultra-wide foundation pits on both sides and the protection requirements of the operating subway.

According to Zhejiang Province's "Technical Regulations for Safety Protection of Urban Rail Transit Structures", the scope of the subway control protection zone is within 50m outside the outer edge of the tunnel section structure, and the special protection zone is within 5m outside. Combining the engineering and hydrogeological conditions, the safety status of the subway tunnel structure and the degree of external operation impact, the project is divided into a ground protection zone and a special protection zone. According to the location of the ground protection zone and considering the on-site construction conditions, the subway non-impact zone is subdivided into a non-reserved zone and a reserved zone. The non-reserved zone is an area that is not restricted by subway protection and can be constructed first; the reserved zone expands along the edge of the ground protection zone, and the width includes the width of the temporary road and the width of the slope, ensuring that it does not affect the construction of the underground structure and the ground steel structure of each exhibition hall, and can be used as a temporary road for the construction of the non-reserved zone and the ground protection zone.

4 FINE CONSTRUCTION DEPLOYMENT TECHNOLOGY OF SUPER-LARGE-SCALE PILE GROUPS CLOSE TO THE SUBWAY

This project uses cast-in-place piles under the large roof columns of the exhibition hall and the basement columns within the influence range of the subway; prestressed high-strength concrete pipe piles are used under the ordinary basement columns. In order to deal with the soil squeezing effect that may be caused by the construction of super-large-scale pile groups around the subway, the following construction deployment is proposed: prefabricated pipe piles in the exhibition hall area → cast-in-place piles in the reserved area → cast-in-place piles in the ground protection area → cast-in-place piles in the central corridor, with symmetrical reverse construction on both sides. The reserved area serves as a stress buffer zone for prefabricated pipe piles to ensure the safe and stable operation of the subway.Symmetrical reverse construction deployment of the overall pile foundation can be seen in Figure 1.

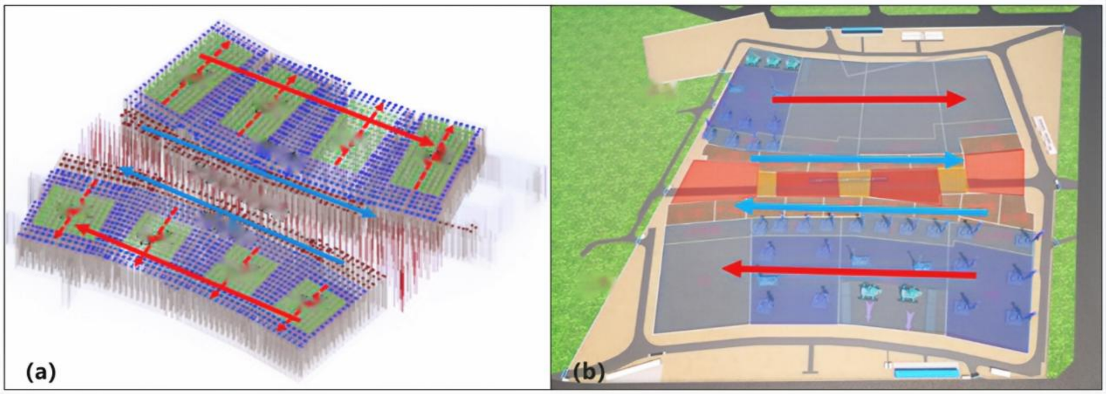

Figure 1 Symmetrical Reverse Construction Deployment of the Overall Pile Foundation

Just like Figure 2, pipe pile construction deployment in non-reserved areas: The South Exhibition Hall is constructed from north to south (4#→3#→2#→1#), and the North Exhibition Hall is constructed from south to north (8#→7#→6#→5#). The piles are injected from near to far on one side of the subway tunnel to prevent or slow down the lateral soil squeezing stress transmission caused by the construction of prefabricated pipe piles and reduce the disturbance to the subway tunnel.

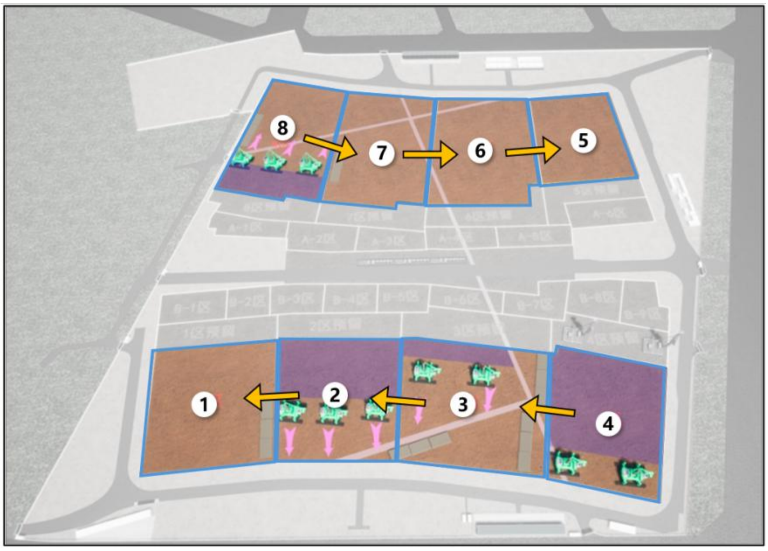

Figure 2 Pipe pile construction deployment in non-reserved area

In Figure 3, construction deployment of bored piles in reserved areas and ground protection areas: Combined with the overall deployment of pile foundation construction and the subway protection safety assessment report, the construction organization of bored piles in reserved areas and ground protection areas is refined. The direction of pile foundation construction in the southern reserved area is from east to west, and in the northern reserved area is from west to east, following the principle of skipping every 10m.

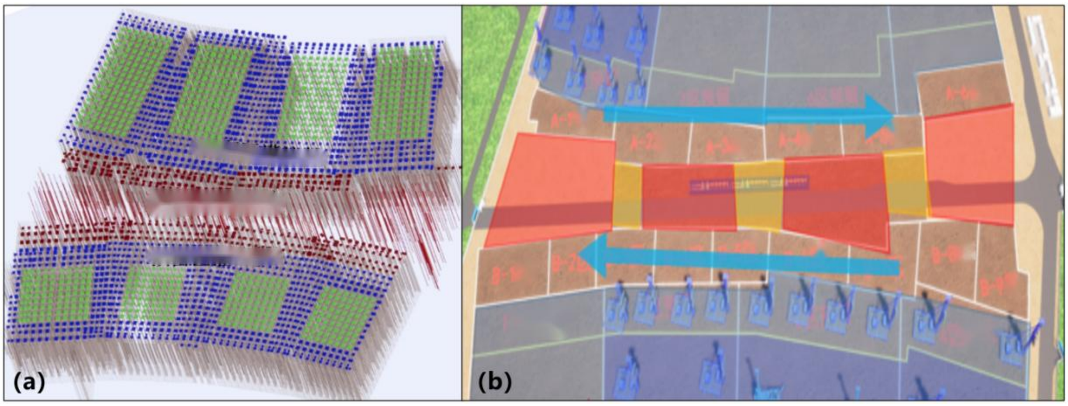

Figure 3 Construction deployment of cast-in-place piles in reserved area and ground protection area

In Figure 4, construction deployment of cast-in-place piles in the central corridor: The cast-in-place piles in the central corridor are located around the subway tunnel. The piles are 78m long and difficult to construct. The key is to control the micro-disturbance of cast-in-place pile construction on the existing subway tunnel. Through trial pile construction, the pile foundation construction method is analyzed and optimized. First, the pile foundations on both sides of the subway are constructed, and then the pile foundations in the middle of the tunnel are constructed, following the interval of 20m.

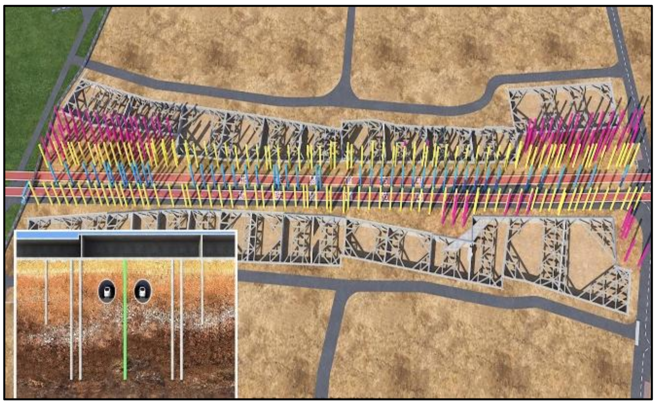

Figure 4 Construction deployment of cast-in-place piles in the central corridor

5 CONSTRUCTION ORGANIZATION AND CONTROL TECHNOLOGY FOR LARGE-AREA BASEMENT SLABS

In Figure 5 and 6, the basement of this project adopts a refined construction strategy of large-area small-block skipping combined with large temperature post-casting strips. The "T"-shaped temporary roads on both sides are used as temperature post-casting strips, which saves 15% of the construction period and solves the problem of temperature cracks in large-area basement slabs.

According to the functional zoning and subway protection requirements, the on-site slab construction is divided into 18 zones. Among them, the exhibition hall is divided into zones 1 to 8 and their corresponding reserved areas, a total of 16 large zones; the subway protection zone is a separate large zone, which is subdivided into zones A-1 to A-6 and B-1 to B-8. On this basis, each large zone is subdivided twice according to the principle that the side length does not exceed 40m and the area is less than 1600 m2.

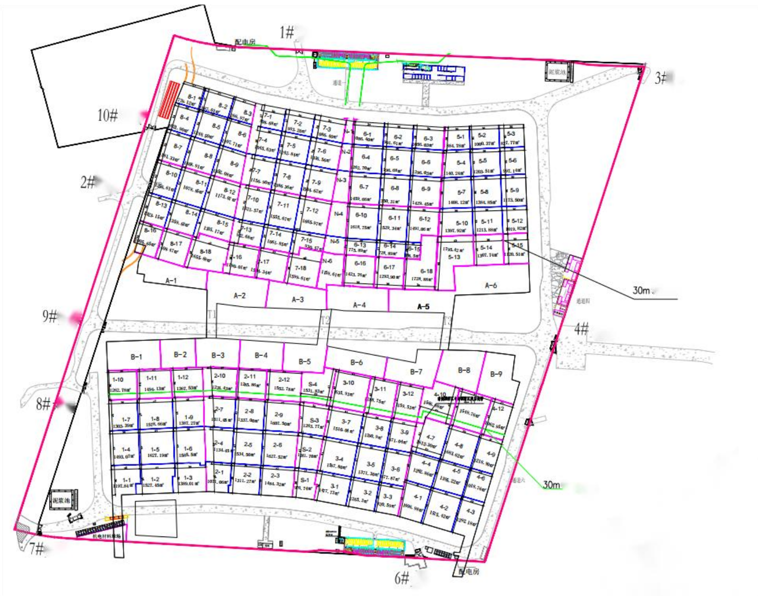

Figure 5 Partition Layout

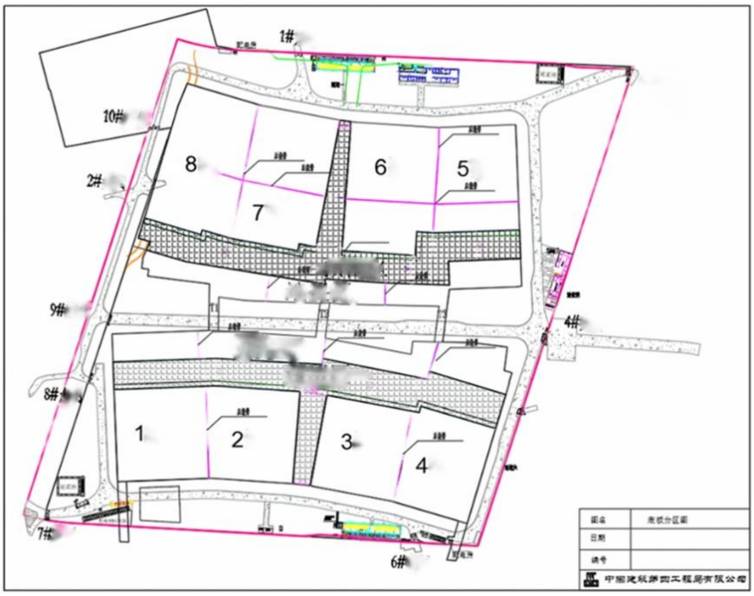

Figure 6 Plane Layout of Post-Casting Strip

In Figure 7, the pouring of the base plate is divided into five stages: the first stage: South Area 4 and North Area 8; the second stage: South Area 3, Area 2 and North Area 7, Area 6; the third stage: South Area 1 and North Area 5; the fourth stage: the ground conservation area; the fifth stage: the South reserved area and the North reserved area (Figures 7 and 8).

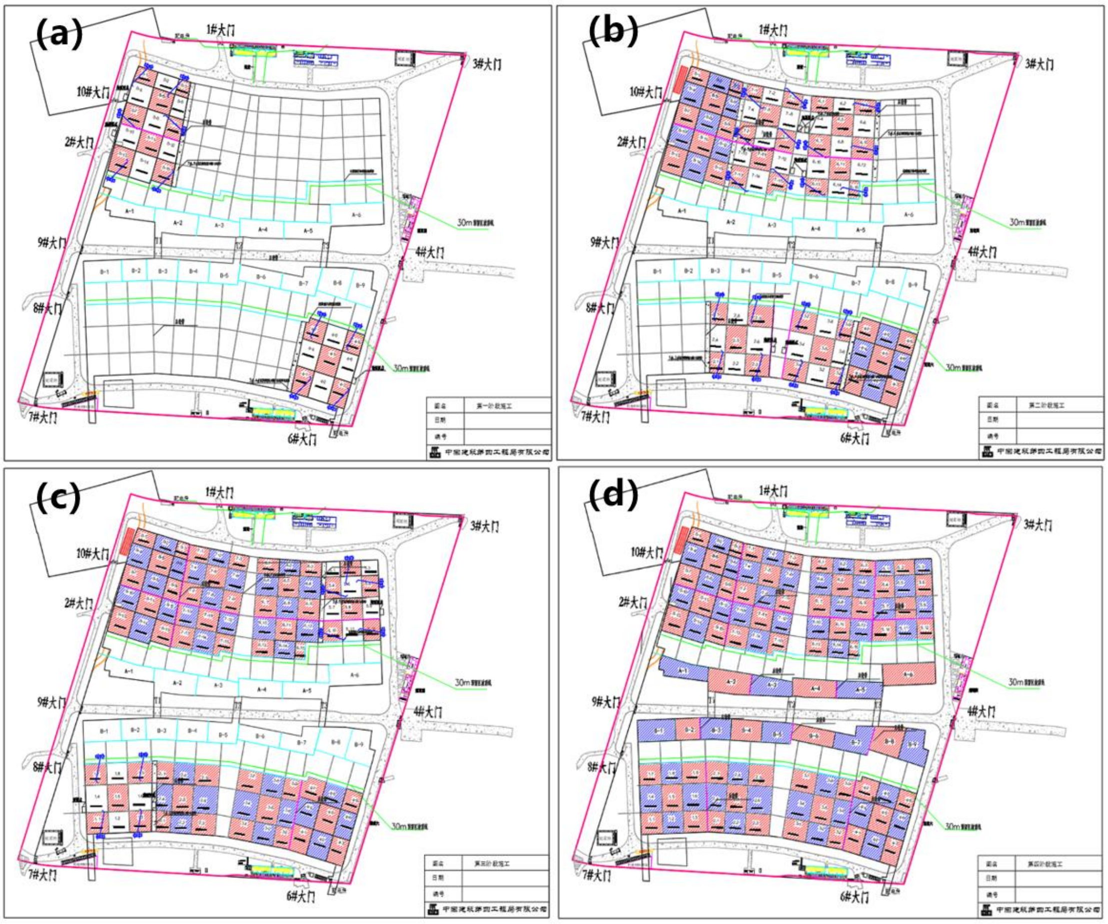

Figure 7 Phased Construction Deployment of Ultra-Large Area Base Plate

6 CONCLUSION

This study applied the fine control technology of super-large space construction adjacent to the subway to solve the construction problems of super-large underground space in sensitive environment. The main conclusions are as follows:
(1) A bilateral symmetrical large-division overall deployment strategy is proposed to ensure efficient construction of the foundation pit while meeting the protection requirements of the subway.
(2) In view of the soil squeezing effect of pile groups, a bilateral symmetrical reverse construction mode is adopted to reduce the impact on the subway.
(3) The large-division small-block skipping strategy is adopted in the construction of the basement floor, which saves 15% of the construction period and solves the problem of temperature cracks.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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