Volume 2, Issue 2, 2024

Print ISSN: 2960-0235

Online ISSN: 2960-0243

ACADEMIC JOURNAL OF ARCHITECTURE AND CIVIL ENGINEERING

Academic Journal of Architecture a nd Civil Engineering

Volume 2, Issue 2, 2024

Published by Upubscience Publisher

Academic Journal of Architecture and Civil Engineering
Print ISSN: 2960-0235 Online ISSN: 2960-0243
Email: info@upubscience.com
Website: http://www.upubscience.com/

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajacev2n201

IN-DEPTH RESEARCH ON QUALITY CONTROL OF ROAD AND BRIDGES IN HIGHWAY CONSTRUCTION

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Abstract: Due to the large scale, long construction period and complex geographical environment of highway construction, the construction quality of roads and bridges directly affects the overall construction quality of highways. This paper analyzes the main problems and reasons affecting the construction quality of roads and bridges, and proposes control measures to improve their construction quality, in order to strengthen the construction quality of highways and promote the healthy development of the transportation industry.
Keywords: High-speed construction; Roads and bridges; Quality control

1 MAIN ISSUES IN ROAD AND BRIDGE CONSTRUCTION

1.1 Quality of Construction Materials

In any construction project, the quality of construction materials is the core of the overall construction quality. In the construction of roads and bridges, high-quality construction materials are the guarantee and focus of road construction quality. When purchasing specific raw materials, especially reinforced concrete materials, relevant personnel must strictly follow the standards and strictly inspect their quality to provide basic guarantee for later construction. Resolutely prevent some units or personnel from using substandard construction materials for immediate or their own economic interests, thereby causing serious hidden dangers to the construction quality and later safe use of roads and bridges.

1.2 Cracks on Roads and Bridges

Highway construction will face different weather and geographical environments, and the weather environment will have an important impact on highway construction. During the construction of road bridges, cracks of varying degrees often occur in road bridges due to changes in temperature, which affects the overall quality of the construction. When the temperature is below 0°C, water will condense into ice. Therefore, when the construction temperature of roads and bridges is below 0°C, the moisture in the concrete will automatically condense into ice, directly reducing the overall strength of the concrete and affecting the structure of the concrete. Quality has serious consequences. At the same time, due to changes in the structure of the concrete, shrinkage stress occurs inside the structure. When it exceeds a certain range, cracks will appear in the concrete structure to varying degrees, which seriously restricts the improvement of the construction quality of roads and bridges.

1.3 Problems with Mechanical Construction Equipment

Mechanical construction equipment is the basis for improving the efficiency of road and bridge construction, and its quality and operation are the key to ensuring the construction cycle. In the current road and bridge construction, some construction units lack a complete mechanical construction equipment supervision system, which makes some mechanical equipment malfunction more and more frequently during the construction process. This not only delays the completion of the construction plan, but also affects the construction quality. There is a direct impact.

1.4 Corrosion Problem of Steel Bars

The quality of steel bars plays a decisive role in the quality of the entire road and bridge project and the safe use in the later period. If the steel bars are corroded during construction, it will directly reduce the quality and service life of the road bridge, and even threaten people's lives and property. Usually, there are many factors that cause the corrosion of steel bars, mainly the specific construction environment and construction technology, as well as the harsh natural environment (exhaust gas, acid rain or other corrosive environments) during the construction process, which will cause corrosion of the steel bars, thereby directly reducing the strength of the steel bars. Durability and durability have a negative impact on the overall construction quality.

2 BASIC REASONS FOR QUALITY PROBLEMS IN ROAD AND BRIDGE CONSTRUCTION DURING HIGH-SPEED CONSTRUCTION

2.1 Construction Personnel Lack High Professional and Technical Levels

Construction workers lack corresponding professional knowledge and operating skills, making their own professional skills generally low, which has a certain impact on the quality of expressways. Due to the lack of professional skills of the relevant construction personnel, it directly led to problems with the overall construction quality, shortened the original safe use period, and also increased the later maintenance costs. The construction personnel of some enterprises do not have the corresponding professional knowledge, and some even do not construct according to the design drawings but based on their own experience; some construction personnel lack the corresponding professional ethics and do not obey the arrangements of the management personnel or directly refuse to implement them. its requirements; some construction workers do not respect new technical personnel, etc., which will have a negative impact on the overall quality of the construction bridge.

2.2 Errors in Actual Construction Lead to Deviations in Measurement and Calculation

With the rapid development of the construction industry, higher requirements have been placed on the professional skills and comprehensive quality of construction personnel. But this is not the case. Most of the front-line workers in road construction in our country currently do manual labor and generally have low educational levels. At the same time, construction companies neglect to provide professional construction technology training to workers. , making professional skills and comprehensive literacy generally low. Therefore, there are certain difficulties in understanding the specific construction plan, and it is easy to make mistakes during the actual operation, causing deviations in relevant measurements and calculations, and giving wrong guidance to later work. At the same time, due to the low education level of construction workers, some construction workers will only operate based on subjective consciousness and ignore relevant construction operation requirements, which will inevitably directly affect the overall quality of the construction.

2.3 Failure to Pay Attention to Hidden Projects during Construction

Under normal circumstances, after the construction of a road bridge is completed, professional institutions and staff will conduct strict acceptance and evaluation. However, often only the external structure and quality of the road bridge can be inspected. The internal structure of the road bridge Some hidden problems cannot be discovered and inspected in time, which will bring safety risks to the later use of roads and bridges. Therefore, during the final acceptance and evaluation, the relevant departments should strengthen the inspection of hidden works in the project, such as the binding of steel bars and the fixing method of welded joints, etc., to conduct careful and comprehensive inspections to try to avoid these problems. The overall quality of roads and bridges is damaged. If any emergencies occur on the bridge during transportation, it will cause serious harm to the bridge, traffic and people. Even after effective repairs, it will also bring safety hazards to later use. Therefore, during the initial construction process of the bridge, the construction quality should be strictly guaranteed to avoid cracks in the bridge and ensure the construction quality.

3 MAIN MEASURES TO IMPROVE THE QUALITY CONTROL EFFECT OF ROADS AND BRIDGES

3.1 Strictly Supervise the Specific Construction Quality of Roads and Bridges

1) During the specific construction process of roads and bridges, construction companies should pay attention to the supervision of construction quality, arrange professional supervisors in a scientific and reasonable manner, and strictly supervise the quality of various construction projects in strict accordance with the construction standards and requirements of roads and bridges. If If any problems are discovered, they will be pointed out and rectified promptly to ensure construction quality.
2) Construction enterprises should comprehensively improve the professional knowledge and skills of construction supervisors, improve their safety awareness and professionalism through training, examinations, etc., so that supervisors can serve project supervision in a better state and promote the improvement of project construction quality. .
3) In the long-term construction of roads and bridges, construction companies must avoid artificially lowering the construction process requirements due to the lax subjective consciousness of construction personnel, and relax the quality inspection of hidden projects during construction, which may bring hidden dangers to safe use in the later period.
4) The construction unit can improve the work enthusiasm and construction efficiency of construction personnel and ensure the overall construction quality by establishing a reasonable performance appraisal system.

3.2 Scientifically Deal with the Problem of Bridge Cracks

During high-speed construction, bridge cracks will directly affect the service life of the bridge. Construction companies should attach great importance to and effectively deal with bridge cracks through scientific means to ensure bridge quality. During the initial construction of the bridge, especially during the pouring of concrete, attention should be paid to the quality monitoring of construction details. For example, for concrete that has been mixed, temperature control measures should be taken in time before entering the mold to avoid excessive temperature differences. The concrete expands from the inside out, causing cracks in the bridge. Secondly, during the concrete pouring process, the layered pouring operation method should be adopted, combined with corresponding auxiliary measures, to ensure the pouring quality and improve the quality of the bridge construction. In addition, attention should be paid to the operational details and related maintenance measures during the construction process to ensure that the concrete is vibrated evenly during the pouring process. Sunshading and water replenishment measures should be taken for some construction projects to ensure the construction quality and extend the safe service life of the bridge.

3.3 Timely and Efficient Construction Supervision

1) Timely and efficient construction supervision by project supervisors is an important aspect to improve the quality of road and bridge construction. Construction companies should reasonably divide the supervision areas of supervisors based on the characteristics of the project to ensure the quality of supervision. Establish and improve construction quality supervision and rectification measures and systems to provide basis and guarantee for the specific work of project supervisors. 2) Timely records should be made of quality problems during specific construction to provide a basis for later rectification. 3) Construction companies should pay attention to the training of professional knowledge and skills of supervisors, comprehensively improve their own professional ethics and comprehensive qualities, and ensure that specific engineering construction and project supervision can be carried out harmoniously.

3.4 Construction Enterprises Strengthen the Training and Introduction of Professional Talents

The current serious overloading, excessive vehicle speed and other factors will directly affect the service life of road bridges, so it will make subsequent road and bridge maintenance work more difficult. Therefore, strengthening the training and introduction of professional talents by construction companies is not only the basis for ensuring construction quality, but also the key to improving the quality of subsequent road maintenance. Construction enterprises should strengthen professional skills training for construction personnel, provide more opportunities for exchange and learning, introduce new talents with advanced concepts in a timely manner, establish a scientific assessment mechanism, improve the work skills and enthusiasm of construction personnel and management personnel, and ensure Overall construction quality.

4 CONCLUSION

Road and bridge construction in high-speed construction is an important part of my country's infrastructure construction. To effectively improve the construction quality of roads and bridges, scientific control measures should be taken, construction technology should be optimized, and relevant resources should be reasonably allocated to ensure the overall construction quality and promote traffic. Sustainable development of the transport industry.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajacev2n202

COMPREHENSIVE ANALYSIS OF FACTORS AFFECTING ROCK AND SOIL STABILITY

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Abstract: With the advancement of construction equipment, materials and theoretical technology, the quality of geotechnical engineering in my country has been greatly improved. However, due to the diversity and complexity of construction conditions and later damage factors, the stability of geotechnical engineering is still It is difficult to meet today's needs. Therefore, it is of great practical significance to systematically study the factors affecting the stability of rock and soil mass and summarize the weak points.
Keywords: Rock and soil mass; Stability; Influencing factors; Construction guarantee

1 INTRODUCTION TO ROCK AND SOIL BODIES

Rock and soil mass is a very common form of geographical environment in human life and is closely related to many people's activities. Especially in the civil engineering industry, construction rock and soil mass, foundation pit rock and soil mass, etc. often appear in various engineering projects. Under construction. With the continuous expansion of economic construction in recent years, more and more rock and soil engineering projects have been carried out, and the stability of rock and soil bodies and their natural disasters have always been hot issues in the engineering field. The development of China's social economy has led to the rise of various construction industries. In the context of economic integration, the construction industry, as one of the important pillar industries of the national economy, has ushered in new opportunities and challenges in construction.

1.1 The Importance of Rock and Soil Stability

Geotechnical engineering involves multiple disciplines, mainly including engineering mechanics, rock mass mechanics, supporting structures, construction management and technology, building materials and measurement, etc. The research requires high cross-disciplinary requirements. At the same time, rock and soil bodies have a tendency to automatically move downward in their natural state. Coupled with factors such as pressure, friction-reducing effects of intergranular fluids, and incompleteness caused by cracks, rock and soil bodies are very prone to instability and collapse. Rock and soil instability can induce a series of natural disasters such as debris flows and landslides, which are very common in mountainous areas. During the construction process, if the rock and soil support is improper, instability may easily occur, which will cause huge losses to people's lives and property and increase social instability. Due to the development of local economy, over-exploitation of land, destruction of vegetation, large-scale mining of rocks, etc., geological disasters of rock and soil have become increasingly common, and the country and people have suffered heavy losses. Due to the complexity of rock and soil management factors and the diversity of action mechanisms, rock and soil management is still a focus and difficulty.

1.2 Classification of Rock and Soil Bodies

The classification of rock and soil bodies is shown in Table 1.

Table 1 Classification of rock and soil bodies

Classification basis	Rock and soil body name	Overview of rock and soil body types
Rock mass type	Rock type building rock and soil mass	This kind of building rock and soil is mostly rock and can be subdivided according to the type of rock mass.
	Soil type building rock and soil mass	This kind of building slope is composed of soil. According to the soil type, there are overlapping soil and stone types, mixed soil and stone types, etc.
rock and soil stability	Stable building rock and soil mass	This type of rock and soil mass has high stability and will not deform. It is a target type of rock and soil mass protection.
	Unstable building rock and soil mass	Local damage has occurred and protective treatment is required
	Unstable building rock and soil mass	The stability of the rock and soil has been completely destroyed and requires thorough protection or re-construction.
Slope of rock and soil mass	Moderate building rock and soil mass	Slope less than 15°
	Medium steep building rock and soil mass	The slope is between 15° ~ 30°
	Steep building rock and soil mass	The slope is above 60°

2 ANALYSIS OF FACTORS AFFECTING ROCK AND SOIL STABILITY

From the perspective of factors affecting the stability of rock and soil masses, they are mainly divided into internal factors and external factors. Among them, internal factors mainly include the basic characteristics of rock and soil masses, such as geological structure types, rock and soil mass structural characteristics, etc. From the perspective of influence time, these influencing factors are often relatively long-term and are also the main factors causing the loss of stability of rock and soil mass. In essence, these internal factors have a decisive influence on the form and scale of rock and soil bodies. Not only that, these factors also have a great impact on the weathering, shape, vibration load, meteorological conditions and plant growth of the rock and soil mass.

2.1 Stratigraphy and Lithology

Differences in stratigraphy and lithology will affect the rock and soil bodies, and differences in time and origin will cause the rock and soil bodies to be destroyed and take on different forms. Because they all have different physical and chemical properties, the reduction in the shear strength of the rock and soil media and the increase in the shear stress will ultimately lead to instability and damage to the rock and soil mass.

2.2 Rock Mass Structure

One of the important factors affecting rock and soil mass is the structure of the rock mass itself. We usually divide the structure of rock mass into multiple aspects, including layered, massive, bulk and fragmented network structures. Their different structural forms will have certain differences in physical properties, and the properties that ultimately lead to the damage to the rock and soil mass are also different.

2.3 Weathering

After being exposed to the natural environment for a long time and being eroded by wind and rain, the rock and soil mass will slowly produce corresponding weathering phenomena, and the stability of the rock and soil mass will also gradually decrease.

2.4 Groundwater

The influence of groundwater on the stability of rock and soil cannot be ignored, including erosion, softening, and dynamic and static water pressure. As the name suggests, groundwater has a buoyant effect on the rock and soil mass, which will reduce the stability of the rock and soil mass and lose its original support, leading to final instability. Groundwater can soften the rock and soil in the sliding zone of the rock and soil mass, reduce the overall strength of the rock and soil mass, and thereby cause instability of the rock and soil mass. The water inside the rock and soil mass mainly comes from rainfall, forming groundwater through infiltration. This groundwater fills the gaps between the rock and soil, increasing the self-weight of the soil mass per unit volume. At the same time, the water pressure in the gaps and pores increases, aggravating the dynamic and static water. pressure, which is another form of groundwater. From the perspective of other effects, groundwater has a lubricating effect on the soil, that is to say, the groundwater forms a complex force on the rock and soil, that is, the interaction between water and rock and soil is formed. In a sense, groundwater is not only the internal cause of instability of rock and soil, but also plays a negative influence in the gradual deformation and destruction of slopes.

2.5 Vibration Effect

Natural earthquakes, man-made blasting and other factors will produce certain vibrations, which will seriously damage the stability of the rock and soil mass. The transverse waves and longitudinal waves generated by various strong vibrations will cause the structure of the rock and soil mass itself to deteriorate. Changes have caused landslides and reduced the stability of rock and soil.

2.6 Basic Forms of Rock and Soil Failure

From the classification of failure forms, rock slope instability can be divided into two types: rock collapse and landslide. Collapse occurs in rock slopes where the rock and soil mass are too steep. Large pieces of rock mass separate from the rock slope and fall forward, or the rock mass at the top of the slope falls off for some reason and rolls down and accumulates at the foot of the slope. It often occurs on slopes. Where the apical cleft develops. It is mainly due to weathering that weakens the cohesion of the joint surfaces, or due to rainwater seeping into the cracks and generating crack water pressure; it may also be caused by changes in temperature, freezing and thawing of loose rocks. Other accidental factors include swelling pressure caused by plant roots, earthquakes, and lightning strikes.

Landslide is the overall sliding of rocks along the weak structural surface in the slope under the action of gravity. The main types of landslides include plane sliding, wedge sliding and rotational sliding. The rock slope sliding process can be roughly divided into three stages: ① Creeping deformation stage. Cracks appear on the slope surface or on the top of the slope and gradually lengthen and widen. Extrusion occurs on the front edge of the slope. The groundwater level changes, and sometimes there is a sound. ②Sliding failure stage. The rear edge of the slope subsides rapidly, and the rock mass slides downward at a very high speed; ③ Gradually stable stage. The loose sliding body gradually becomes denser, vegetation gradually grows on the sliding body, and the groundwater seepage changes from muddy to clear.

3 TECHNICAL PROBLEMS AND SOLUTIONS FOR ROCK AND SOIL CONSTRUCTION

3.1 Geotechnical Survey

Before carrying out support design for building geotechnical engineering, staff must fully understand the geotechnical properties of the geotechnical mass, and the construction unit should provide geotechnical engineering data. During the survey process, effective supplements should be made based on the characteristics and actual conditions of the rock and soil mass to ensure that the rock and soil survey data meet the needs of design and construction. When carrying out the construction of rock and soil engineering, it is necessary to clarify the purpose, conduct a detailed survey of the hydrogeological conditions and the basic situation of the project, determine the type of rock and soil and possible damage forms, and then make scientific and reasonable decisions on the stability of the rock and soil. evaluate.

The general steps of rock and soil mass survey are: find out the engineering geological conditions of rock and soil mass, determine the category of rock and soil mass, further provide various parameter values required in the process of rock and soil body stability calculation, and propose potential impacts on rock and soil mass stability. Based on the specific treatment plan and measures, the remediation and design considerations of the rock and soil mass can be obtained. For rock and soil engineering projects with safety levels of one and two, it is necessary to draw geological vertical and horizontal sections of the rock and soil mass, and analyze the geology of the entire rock and soil mass. Conduct a detailed survey.

3.2 Soil and Rock Engineering Aspects

The instability of soil and rock mass engineering is the primary problem to be solved in geotechnical engineering. We usually use the following measures to improve the instability of soil and rock mass engineering: ①Plant trees. By adding vegetation measures to the rock and soil mass, the soil slope can be effectively reinforced, and it can also be used in conjunction with other greening, so that the slope can form a more complete protective layer. ② Mortar masonry rubble protection. This method is used for soil slopes with a slope ratio less than 1:1. The thickness of the mortar rubble is generally 0.2 to 0.5 m, and expansion joints and drainage holes should be installed in between. For embankment rock and soil, if the subgrade settlement is unstable, then the masonry rubble should be The method of mortar-laying rubble slope protection should not be used. ③Concrete precast block protection. It is mainly used in areas lacking block stone materials and can achieve a certain degree of aesthetics. ④Face wall protection. For rock formations with severe surface weathering, including chlorite schist, dry schist and other similar soft rocks, the protection of the protective wall is particularly important. The main external force it bears is its own gravity and does not bear other loads, including the wall. The subsequent earth pressure. The excavation slope for protection of the protective wall should meet the ultimate stability requirements of the rock and soil mass. The bottom width of the protective wall is generally required to be 0.4 ~ 0.6 m, the top width is 0.4 ~ 0.6 m, and the wall height is H/ 10 ~ H/20.

3.3 Geotechnical Engineering Safety Monitoring

At present, for the monitoring of geotechnical engineering, there are many types of monitoring instruments available. The main monitoring methods include geodesy, ground photogrammetry, electromechanical measurement and internal deformation monitoring. The instruments selected for each monitoring method Not exactly the same, and so is the accuracy. During the implementation of geotechnical engineering, blasting, excavation, loading and meteorological conditions need to be strictly recorded. When monitoring blasting projects, the possible impact of blasting on the surrounding environment must be fully considered. For earthwork projects, it is necessary to ensure that horizontal and vertical displacement monitoring meet the requirements during monitoring, and the monitoring time should be no less than 3 years. When carrying out geotechnical engineering construction, the design unit should put forward monitoring requirements, and the construction unit should entrust a qualified unit to prepare monitoring methods. The next step of construction can only be carried out after passing the review. 4 Conclusion

There have always been rock and soil stability problems in engineering construction. Landslides and collapse disasters caused by rock and soil instability often bring huge losses of life and property. There are many factors that affect slope stability, and the situation is also relatively complex. In During project construction, it is necessary to analyze the impact of the engineering environment on the stability of the rock and soil mass to provide reliable guarantee for the construction of the project.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajacev2n203

DISCUSSION ON THE REUSE OF WASTEWATER FROM CONCRETE MIXING STATIONS FOR CONCRETE PRODUCTION

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Abstract: With the rapid development of China's construction industry, the development of ready-mixed concrete is also increasing. More and more concrete mixing stations have been established in major and medium-sized cities, promoting the development of commercial concrete. However, concrete mixing stations discharge a large amount of wastewater, which not only pollutes the environment but also wastes water resources. It does not meet the requirements of green environmental protection. However, reasonable and effective utilization has always been a technical problem. To this end, this article mainly studies the effective use of wastewater and waste residue discharged from concrete mixing stations in concrete.
Keywords: Concrete, Mixing station, Wastewater, Utilization

1 INTRODUCTION

When flushing concrete mixer trucks, pump trucks and mixers, a large amount of sewage will be formed. According to relevant statistics, a concrete company with an annual production capacity of 200,000 cubic meters can produce up to 30m3 of wastewater every day[1]. At the same time, this wastewater is not only highly alkaline, and direct discharge will cause alkalinization of the soil and contamination of water resources, but it is also mixed with sand, stone, and incompletely hydrated cementitious materials. If not treated, it will be a waste of resources. It will also block various municipal facilities and pollute rivers, all of which seriously endanger the social environment. In JGJ/T 328-2014 "Ready-mixed Concrete Green Production and Management Technology", "wastewater treatment system" and "wastewater utilization" are included in the green production star rating[2]. In response to these situations, it is necessary to process and recycle this wastewater and replace it with concrete production water. On the basis of ensuring the quality of concrete, it can also purify the environmental sanitation of the mixing station, protect the ecological environment, save water resources, and bring certain economic benefits. Realize "zero discharge" of waste water and waste residue[3].

2 BASIC PROPERTIES OF WASTEWATER DISCHARGED FROM CONCRETE MIXING STATIONS

After the mixing station produces concrete, tap water is generally used to flush the mixing equipment and wash the mixer trucks. The wastewater generated not only contains incompletely hydrated cement, unhydrated admixtures, clay, fine sand and other granular solids, and also contains many hydrated ions, such as Ca^{2+}, OH^{-}, etc. To a certain extent, the solid content is determined by the flushing volume and treatment facilities, the ion concentration is affected by the concrete design ratio, and the wastewater properties are affected by residual admixtures[4]. When testing wastewater, the test indicators are mainly solid content. Relevant research shows that the solid content of wastewater has nothing to do with its pH. When the storage time is extended, various wastewater particles will continue to hydrate and change the ion concentration[5].

3 CURRENT SITUATION

At present, in most wastewater treatment systems of mixing stations, sand and gravel are filtered through sand and gravel separation equipment, and the wastewater is then separated and precipitated. When wastewater is precipitated, it often passes through multiple sedimentation tanks[6]. After the solid particles in the wastewater are precipitated multiple times, a more ideal precipitation effect can be obtained. However, it occupies a large area, and wastewater and waste residue are not utilized, which does not meet the requirements of green environmental protection.
Our station filters through sand and gravel separation equipment to separate sand and gravel for recycling and reuse. The wastewater is directly discharged into the mixing tank (two interconnected hexagonal tanks with a diameter of 3.5m and a depth of 4.0m and equipped with stirring blades) and is stored for later use.

4 TEST ON THE INFLUENCE OF CLEAN WATER AND WASTEWATER ON THE PERFORMANCE AND STRENGTH OF CONCRETE

Raw materials:
(1) Cement: Tower brand P.O42.5R cement, 28-day compressive strength is 50.2MPa. (2) Machine-made sand: medium sand, fineness modulus 2.7, powder content 4.6%.
(3) Gravel: 5mm~31.5mm particle size, continuously graded.
(4) Mineral powder: Fujian Sanming Mineral Powder, S95.

(5) Admixture: finely ground limestone powder, 0.045mm sieve residue <15%.
(6) Clean water: tap water.
(7) Wastewater: wastewater with a solid content of 10%.
(8) Water-reducing agent: Huaxinda high-efficiency water-reducing agent, with a water-reducing rate of 26%.

Table 1 Comparison of clean water and wastewater test data

	clear water		wastewater	
Strength level (pump feed)	C30	C50	C30	C50
Additive content (%)	1.6	1.9	1.8	2.2
Workability	generally	generally	good	good
Initial slump/expansionmm	200/500	210/520	200/500	205/510
Slump/expansion mm in 1 hour	200/490	210/530	200/500	210/510
1.5 hour slump/expansion mm	190/465	190/480	180/460	180/450
Initial setting time (min)	240	225	225	220
Final setting time (min)	485	430	480	420
7-day strength (MPa)	23.8	46.2	24.0	46.0
28-day strength (MPa)	33.6	57.6	33.1	57.2

It can be seen from Table 1 that when wastewater with a solid content of 10% is used as mixing water, although the amount of admixtures increases (the solid content of the wastewater contains incompletely hydrated cement, unhydrated admixtures, clay , fine sand and other granular solids, which will absorb admixtures), but can improve the workability of concrete and have little effect on slump and slump loss, setting time and strength, and can be used completely.

Table 2 Concrete mix ratio (kg/m3)

cement	Mineral powder	admixture	Machine-made sand	1-3 gravel	water	Plus agent
C30230	50	50	810	1064	160	6.0
C50400	100	0	602	1157	140	11.0

Table 3 Effect on carbonization performance of building components (all pumped materials, wall columns, 28-35 days old)

	clear water	wastewater	Remark
C20	1.5mm	2.0mm	
C25	1.5mm	1.5mm	
C35	1.0mm	1.0mm	
C50	0.0mm	0.0mm	

It can be seen from Table 3 that the carbonation coefficients of concrete components stirred with clean water and wastewater are almost the same, and are considered to have no effect.

5 SPECIFIC PRACTICES IN USE

(1) After the sand and stone are separated, the wastewater is directly discharged into the hexagonal mixing tank for mixing,

(2) Keep the water level in the mixing hexagonal tank within a certain range. When the production volume is large and the wastewater is insufficient, use clean water to supplement it, that is, control the relatively stable solid content, (3) Install an automatic stirring device in the mixing hexagonal tank (Stir for 5 minutes and stop for 90 minutes. If there is no production, stir according to the set program), (4) Cancel the original clean water intermediate bin and directly extract wastewater to the scale for measurement to prevent sedimentation and material formation at the bottom of the intermediate water bin, (5) Open every day The solid content is measured before production and every 2 hours during production, so that the concrete mix ratio can be adjusted in time to ensure the quality of the factory concrete.

6 DISCUSSION

(1) When using wastewater with a solid content of 10% as mixing water, the amount of admixture should be increased by approximately 0.2% to 0.3%. (2) The workability of concrete becomes better, and the sand rate can be appropriately reduced by about 1%. (3) It has little effect on slump, slump loss, setting time and strength. (4) Further tests are required on the carbonization performance and durability of concrete components. (5) Since the mixing tank realizes continuous automatic control of mixing, the placement time of wastewater has little impact on the performance of concrete.

7 CONCLUSION

Through the wastewater recycling system, the concrete mixing station can recover wastewater in concrete preparation for recycling. By using a sand and stone separation system with a simple overall structure and easy installation and use, and a hexagonal mixing tank with an automatic mixing device, the solid content of the wastewater can be controlled relatively stably, and the wastewater from the mixing station can be recycled and used to achieve zero discharge of wastewater and waste residue. This not only It avoids waste of resources, reduces the actual production cost of the concrete mixing station, and reduces the problem of large sedimentation tanks and large floor space, meeting the requirements of a green and environmentally friendly mixing station.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajacev2n271

THOUGHTS ON THE REFORM OF UNDERGRADUATE TEACHING IN CIVIL ENGINEERING MAJORS IN THE BIM ERA

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Abstract: The emergence and development of BIM technology has triggered another revolution in the construction industry. How to promote BIM technology and how to cultivate BIM technology application talents is an urgent problem that needs to be solved in front of major universities. Based on the preliminary results of the teaching reform of civil engineering majors at home and abroad, this article discusses the teaching objectives, teaching content, and teaching organization form of BIM courses, analyzes the problems faced by the BIM teaching reform of civil engineering majors, and proposes the integration of BIM knowledge into civil engineering. Implementation suggestions in engineering major teaching provide reference for the establishment of BIM courses in civil engineering majors and BIM teaching reform.
Keywords: Civil engineering; BIM; Undergraduate teaching reform

1 CURRENT STATUS OF BIM TECHNOLOGY APPLICATION AT HOME AND ABROAD

BIM (Building Information Modeling) was first proposed by a team of American engineers based on the concept of "virtual construction technology". It implants the engineering information of the "full life cycle" of the building into the computer three-dimensional data model, thereby providing a detailed expression of the engineering project. It has intuitive expression, facilitates the collaborative work of various departments, and can simulate a certain life moment of the building. Deduction characteristics, and can propose optimization measures based on simulation deduction, and finally form a reasonable and feasible technical solution to be output and expressed. [1] BIM technology is actually a large-scale information data platform that associates a large amount of construction project-related information with three-dimensional digital models, and can be easily called at any time to simulate the shape of the building in a certain period of time. In this data platform Engineering and technical personnel can realize the rapid sharing and transmission of information, thereby ensuring the smooth progress of collaboration, acceptance inspection, operation management and other aspects of the project investment, construction, operation and maintenance and other processes.

BIM technology was first proposed by American engineers around 2000, and its prototype is "virtual construction technology". Since its introduction, it has attracted attention and recognition from the engineering and technical circles. As of 2012, BIM technology coverage of engineering projects in the U.S. construction field has reached 71%; at the beginning of the birth of BIM technology, the United Kingdom also specified a detailed BIM technology promotion plan and required that engineering project collaboration based on BIM technology be fully realized by 2016. management; in 2010, South Korea also proposed a ten-year development plan for BIM technology, preparing to establish a complete BIM technology application system for large public buildings by 2020. According to BIM technology implementation cases in foreign engineering projects, the application and implementation of BIM can reduce engineering project changes by 60%-70%, enable engineering and technical personnel to save 20%-30% of collaborative docking time, and accelerate project progress by 5%-10%. , and at the same time reduce project expenses by an average of about 1.5%. [2] With the birth and rapid development of BIM technology, the era of traditional planning, design, construction, operation, maintenance and management based on two-dimensional CAD drawings will be gone forever. Its production and promotion is another production technology revolution in the field of construction manufacturing after two-dimensional CAD drawings replaced manual drawings. It will bring profound changes to the construction industry and related industries, and in the near future will become an important technical means for construction projects to be applied in the "full life cycle of construction projects".

While BIM is developing in full swing abroad, BIM technology is gradually being exposed and recognized by Chinese engineering and technical personnel. In 2005, my country's first BIM laboratory was established under the joint initiative of South China University of Technology and AUTODESK. In 2010, Tsinghua University organized scientific and technical personnel to tackle key problems and creatively proposed the China Building Information Model Standard Framework. Based on this model standard framework, it further proposed IT technology standards for the technical layer and user implementation standards for the application layer. [1] In 2011, the Ministry of Housing and Urban-Rural Development issued a guiding document for the development of BIM technology, the "2011-2015 Construction Industry Informatization Development Outline", which clearly emphasized that during 2011-2015, breakthroughs in

information technology in the construction engineering field will be made We will speed up the establishment of a building information platform based on "Internet +", launch guiding standards and technical regulations for building information construction, break foreign technology monopoly, and gradually establish a software information platform with independent intellectual property rights to make my country's building information Technology has gradually reached the international advanced level. In January 2012, the Ministry of Housing and Urban-Rural Development issued the "Notice on Issuing the Revised Plan for the Development of Engineering Construction Standards and Specifications in 2012". The "Notice" puts the formulation of BIM technical standards and procedures on the agenda, and establishes the first five BIM technical standards to be released. In August 2013, in order to accelerate the promotion and application of BIM technology in the field of construction engineering, the Ministry of Housing and Urban-Rural Development issued a "Letter on Soliciting Guidance on Recommending the Application of BIM Technology in the Construction Field." It clearly states that after 2016, all government public construction projects involving more than 20,000m2 and green building projects must apply BIM technology for project management in their design and construction stages; before 2020, the national BIM technology application standards and procedures will be improved. Implementation Guidelines formulate policy outlines to encourage the application and promotion of BIM technology at the national level; and stipulate that BIM technology must be implemented compulsorily in projects applying for construction awards at all levels (such as the Luban Award, survey and design awards at all levels, and regional engineering quality awards). In September 2016, the Ministry of Housing and Urban-Rural Development issued the "2016-2020 Construction Industry Informatization Development Outline" to further clarify the development goals and significance of my country's construction information industry during the 13th Five-Year Plan period.
The promotion and application of BIM technology in the field of construction engineering in my country is imperative, and Chinese educators have begun discussions on curriculum reform based on BIM technology. Zeng Wenhai et al. analyzed the current situation of teaching in colleges and universities today and suggested incorporating the BIM curriculum system into practical teaching [2]; Hao Li proposed a summary of various forms of integrating BIM technology into teaching [3]; Zhao Xuefeng et al. drew lessons from foreign BIM education model, and proposed a BIM course teaching system suitable for China [4]; Liu Hongyong et al. discussed the feasibility of starting BIM courses in colleges and universities, and put forward suggestions on the content, goals, methods and methods of BIM teaching [5]; Li Yanfeng compared developed the training programs for civil engineering majors in China and the United States, and put forward several suggestions for domestic civil engineering education [6].

2 CIVIL ENGINEERING PROFESSIONAL TALENT TRAINING PLAN BASED ON BIM TECHNOLOGY

2.1 About the Talent Training Goals of BIM Technology Courses

According to the differences in the application of BIM technology at home and abroad, in view of my country's civil engineering talent training system and development direction, the popularization of BIM technology should first be carried out in colleges and universities. By formulating corresponding talent training mechanisms and setting up corresponding curriculum systems, we strive to achieve the following training goals in BIM technology education at the undergraduate level:
(1) Understand the concept, application and development direction of BIM, clarify the status and role of BIM technology in the future development of civil engineering, and establish the confidence and determination of college students to learn BIM technology.
(2) Familiar with the application of BIM in the architectural design stage, especially 3D modeling and scheme comparison and selection of different structural forms, pipeline synthesis and collision detection, project quantity statistics, etc.; Familiar with the application of BIM in the building construction and management stage, including Establishment of BIM construction models, 4D and 5D construction progress simulation, spatial conflict detection, etc.
(3) Familiar with the use of large-scale BIM general software, including Revit, CATIA, Navisworks, Luban software, etc. For undergraduates, emphasis should first be placed on mastering the modeling software proficiently, and on the basis of being familiar with the modeling software, they should appropriately expand to the model analysis software.
(4) Through BIM course design and graduation project training, understand the new model of building design, construction, acceptance and operation and maintenance management based on BIM technology, and master the use of BIM technology to solve technical problems and strengthen collaborative work methods between different majors. There are varying degrees of differences between various universities in terms of graduate positioning and training goals. Different universities can establish unique talent training models based on their own training goals to target governments, construction units, design units, construction units, operation management units, etc. Multifaceted talent needs.

2.2 Teaching Content of BIM Courses

Establishing BIM-related courses is not simply to add courses on BIM technology to existing courses, but to carry out drastic reforms in the teaching methods and teaching objectives of the existing course system, and to infiltrate the concepts, principles and application methods of BIM. into each course. As far as conventional civil engineering courses are concerned, the teaching contents that can be combined with BIM technology include: Introduction to Civil Engineering, Civil Engineering Drawing, Civil Engineering Materials, Housing Architecture, Concrete Structure Design, Steel Structure Design, Architectural CAD, and Engineering Project Overview. Budget, civil engineering construction, graduation project and related course design, etc.

In addition to combining with existing courses, in order to accelerate the promotion of BIM technology in university education, it is also urgent to open targeted BIM introduction courses and practical courses. These courses include: introduction to the development and application of BIM, conventional BIM software and its Operation methods, BIM and architectural visualization, BIM-based full-professional design and design, BIM and construction simulation and management, BIM-based collision, BIM-based construction progress control and cost control, etc.

2.3 Teaching Organization form of BIM Courses

(1) Classroom teaching of BIM knowledge and technology. Classroom teaching is the most basic teaching method and the most direct teaching method to impart BIM knowledge to students. In BIM classroom teaching, the following contents need to be emphasized: the meaning and application of BIM, the operation of BIM software and the establishment of 3D models, BIM-based construction progress display and management, BIM-based project quantity statistics and project cost control, BIM and various The relationship between majors and their application points in each major. The main goal of BIM classroom teaching is to let students understand the basic knowledge structure of BIM, the application points of BIM in the field of civil engineering, become familiar with the types and application scope of BIM modeling and analysis software, and the operating skills of commonly used BIM software, and solve the problem of "how to learn" BIM" issue.

(2) Practical training teaching of BIM. BIM technology emphasizes the practice and application of knowledge, so BIM practical training teaching is an indispensable form of course teaching organization. The design of practical training content should echo the classroom teaching content, and teaching and practice should be carried out simultaneously to effectively establish students' application and practical operation abilities. BIM practical training teaching can include the following content: operation of BIM modeling software, detailed statistics of project quantities based on BIM models, preparation of schedules and display of construction progress, visualization of design plans, collision analysis, building energy consumption analysis, three-dimensional Visualization technology briefing, etc. All in all, BIM practical training teaching is an extension and in-depth of classroom teaching. Through practical training, students' ability to apply classroom knowledge and their self-confidence and enthusiasm for learning are improved, and the problem of "how to apply BIM" is solved.

(3) Lectures by industry experts on BIM. BIM industry experts have been engaged in BIM application and research on the front lines of engineering projects for a long time. They can provide a new perspective for BIM teaching in civil engineering majors and effectively shorten the distance between classroom and actual engineering applications. Although it accounts for a small share of the entire course teaching, it is very critical. During the teaching process, industry experts often use specific project examples to teach the application of BIM in actual projects and the latest research results. Students can understand the application of BIM in actual projects through example explanations, so that students can clearly understand the necessity of learning BIM. , to solve the problem of "why learn BIM".

To sum up, the three organizational forms of BIM courses are complementary to each other and indispensable. Only when BIM teaching is carried out interspersed with the above three links can its teaching effect be significantly improved.

3 PROBLEMS EXISTING IN BIM TEACHING IN CIVIL ENGINEERING MAJORS

3.1 Insufficient BIM-Related Teacher Reserves in Universities

BIM engineers in the industry today can be roughly divided into three categories based on their job functions and nature, namely relevant standard research and formulation engineers, BIM software development engineers and BIM technology implementation engineers. Among them, BIM technology implementation engineers have the greatest social demand, but there are relatively few practitioners, resulting in a serious imbalance between supply and demand. The training goal of civil engineering majors in universities is to cultivate and transport civil engineering technical personnel to society. In order to make up for the shortage of BIM talents, the reform of talent training models in universities is imperative [7]. The construction of university teacher teams is the soul of higher education. The prerequisite for carrying out BIM teaching at the undergraduate level is the establishment of a team of teachers with BIM professional application capabilities. However, at present, in most colleges and universities, most teachers do not have a deep understanding of the purpose and significance of carrying out BIM teaching practice activities, and have insufficient BIM technology application capabilities, which have seriously affected the implementation of BIM teaching. The BIM model contains a lot of engineering information during the entire life cycle of the project, which requires BIM practitioners to have the ability to operate software and project design and planning, construction, or operation and maintenance management. Therefore, teachers who train BIM practitioners also need to have such abilities. Ability, in order to make BIM teaching and practice smooth and smooth in undergraduate education, it is first necessary to improve the professional quality and ability of the teaching team related to BIM technology.

3.2 Establishing a BIM Teaching Practice System Requires Drastic Reform of the Entire Teaching System

BIM technology aims to establish a complete set of management and control solutions throughout the life cycle of engineering projects. Therefore, the establishment of a BIM technology teaching practice system is not simply to open a few courses on BIM technology knowledge, but to penetrate BIM technology knowledge into all aspects of university civil engineering professional courses, that is, in housing architecture, structural design theory and methods, civil engineering, etc. The teaching of different courses such as engineering construction, engineering project management, project budget, and civil engineering materials is interspersed with the introduction of relevant BIM technical knowledge and the application methods of BIM technology in the course. It is necessary to adopt a new teaching method that integrates and collaborates with multiple courses. . This teaching method is closely integrated with the full life cycle application of BIM buildings and multi-party collaborative applications, which can maximize the teaching effect of BIM technical knowledge. However, teachers of various courses are required to master BIM technology and implement collaborative teaching of multiple courses. However, BIM teachers in various universities are currently relatively scarce, and this type of collaborative education is difficult to achieve in a short period of time.

3.3 There are Many Software Related to BIM, and It is Difficult to Cover Everything Within the Limited Class Time

Currently, there are hundreds of BIM-related software on the market, which can be divided into two categories according to their functions: modeling software and model-using software. Among them, modeling software includes BIM core modeling software, BIM solution design software, and geometric modeling software that interfaces with BIM; while the family of modeling software is even larger, including sustainable (green) analysis software, visualization software, and model checking software. , in-depth design software, comprehensive collision inspection software, cost management software, operation management software, etc. BIM engineers cannot rely on one software to solve all problems, but need to choose different BIM software based on the requirements of the construction unit, the use function of the project, the architectural and structural characteristics, the scale and modeling characteristics of the project. For example, we need to choose a modeling software for BIM3D model modeling. If you are designing a civil building, you often choose Autodesk Revit for modeling; if you are designing an industrial plant or infrastructure, you often choose Bentley series software; if the project building or structural configuration is complex, Digital Project or CATIA software is often the best choice for BIM engineers. software of choice. It can be seen that it is very difficult for students to be fully competent in daily BIM work through limited classroom time and case practice.

4 SUGGESTIONS ON PROMOTING BIM TECHNOLOGY IN UNDERGRADUATE TEACHING OF CIVIL ENGINEERING MAJORS

After CAD technology replaced manual drawing, engineers began to use 2D CAD drawings to express 3D design plans; with the emergence and development of BIM technology, architectural expression methods gradually transitioned from 2D to 3D and 4D. (schedule control dimension) or even 5 dimensions (cost control dimension). BIM technology is a major breakthrough in the design, construction, operation and maintenance of the construction industry, and is the future development trend in the construction field. Strengthening the promotion of BIM technology at the undergraduate level greatly responds to the national applied talent training strategy, so that the entire education stage can effectively apply what they have learned, and on the other hand, it also stimulates students' enthusiasm for learning. However, the teaching of BIM in most domestic universities is still in the exploratory stage.

4.1 Educate College Students on BIM Technology Concepts and Application Fields as Early as Possible so that Students can be Exposed to BIM Technology as Early as Possible

The introduction of BIM concepts and technologies should start from freshmen. It is advisable to set up special topics in professional introductory courses such as Introduction to Civil Engineering, and invite well-known BIM experts or BIM engineers from large design institutes and construction units to carry out BIM training for students. Knowledge lectures. Make students aware of the important impact of BIM on their employment and even future work, realize the importance of mastering BIM technology, and stimulate students' enthusiasm for learning BIM.

4.2 Combine with Existing Teaching Plans and Rationally Plan the BIM Course System

When formulating a BIM teaching plan, students' mastery of professional knowledge, BIM technology, and software practical calculations must be comprehensively considered. The method is adopted to teach BIM technology related to the professional courses while studying professional courses, so that the teaching of professional courses and BIM courses complement each other and are integrated. Here, the author provides a set of feasible curriculum system setting methods for reference (as shown in Table 1).

Table 1 BIM curriculum system for civil engineering majors

Starting grade	Course Title	Course organization format	Course nature	BIM application level
First year undergraduate	Introduction to Civil Engineering	Classroom teaching, expert lectures	Penetration and fusion	3D
Second year undergraduate	architectural drawings	Classroom teaching, practical teaching	Penetration and fusion	3D
	Housing Architecture	Classroom teaching, practical teaching	Penetration and fusion	3D
	building materials	classroom teaching	Penetration and fusion	3D
	building structure	Classroom teaching, practical teaching	Penetration and fusion	3D
Third year undergraduate	Architectural CAD and BIM	Classroom teaching, practical teaching	New courses	3D
	Engineering project management	Classroom teaching, expert lectures	Penetration and fusion	3D, 4D, 5D
	Project cost management	Classroom teaching, practical teaching	Penetration and fusion	3D, 5D
Fourth year undergraduate	Civil engineering construction	Classroom teaching, practical teaching, expert lectures	Penetration and fusion	3D, 4D
	building information modeling	Classroom teaching, practical teaching, expert lectures	New courses	3D
	Graduation Project	practical teaching	Penetration and fusion	3D, 4D, 5D

4.3 BIM Teaching Reform should Adopt a Step-by-Step Approach

The teaching reform of BIM technology cannot be achieved overnight. In order to avoid a "cliff transition" in the teaching reform process from traditional teaching methods to professional knowledge BIM technology integration, it is recommended to adopt a step-by-step approach, that is, first add one or two BIM technology introduction courses to the existing civil engineering training program. This is a comprehensive course, and the teaching content is mainly based on the concepts, applications and software operations of BIM. At the same time, we will gradually strengthen the training of teachers and promote the transformation and transition of teaching content, and accelerate the integration of BIM technical knowledge and existing courses. After the teaching team, teaching material construction, software and hardware facilities are gradually improved, practical learning links that are consistent with the BIM teaching content will be gradually added to enhance students' hands-on ability. Ultimately, a teaching system is formed that integrates BIM technology with other civil engineering professional courses. The implementation steps of the teaching reform can be shown in Table 2.

Table 2 Implementation steps of BIM teaching system reform

stage	Milestones	Teaching content
1	New BIM course	Systematically explains the development and application of BIM technology in detail, suitable for explaining the conceptual application of BIM and the operation of modeling software.
2	Open BIM practice sessions	It simulates and solves practical problems in the form of practical tasks, which is suitable for training the operation of BIM software and multi-party collaborative application capabilities.
3	Opening a graduation project in BIM direction	Training on the comprehensive application of BIM technology is suitable for students with a foundation in BIM technology.
4	Application across multiple courses	The application of BIM technology throughout the teaching of various professional courses is most in line with the full life cycle application characteristics of BIM and is an ideal teaching form.

4.4 BIM Courses Should Mostly Use Case Teaching Methods, and the Teaching Process Should Focus on Cultivating Students' Self-Learning Ability

BIM course teaching focuses on the practical application based on understanding of BIM technology. As many real cases as possible should be introduced during the teaching process to realize virtual design, virtual construction, spatial collision inspection, project schedule preparation, project quantity and project cost analysis, etc. Work to enhance students' understanding of BIM knowledge and improve their ability to apply knowledge.

Among the many cases presented in class, due to the different characteristics of the project itself and the different BIM technology requirements, different software and different BIM technology application methods may be used. Due to limited class time, it is impossible to explain the use of all software and the application process of all BIM technologies during the teaching process. However, we should seize the similarities between many projects and focus on the explanation of application methods and ideas. For detailed issues, students can be asked to self-study. , and understand students' self-study status on time, so that BIM learning can achieve the effect of analogy.

5 CONCLUSION

The emergence of BIM technology is brewing another revolution in the construction industry. The data platform based on BIM technology integrates a large amount of data information at all stages in the entire building life cycle, providing engineering and technical personnel with complete, real-time, and accurate building information, which greatly improves the operating efficiency of the construction industry. Therefore, the most urgent need in the industry in the future will be compound talents who are both proficient in civil engineering technology and have a certain foundation in BIM technology. However, the establishment of a civil engineering teaching system based on BIM technology is still in the exploratory stage. There are still a lot of issues worthy of our college teachers to think about. to solve. Therefore, the introduction of BIM technology is a challenge to today's civil engineering professional education, and it is also an opportunity to develop an applied talent training model. The rapid promotion of BIM technology and its full implementation in the construction industry urgently require all construction departments to actively explore and communicate on BIM teaching reform. Only through continuous exploration on the road of teaching and application can we form a civil engineering major and BIM suitable for our country as soon as possible. Technology-integrated teaching and education program.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajace3005

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.

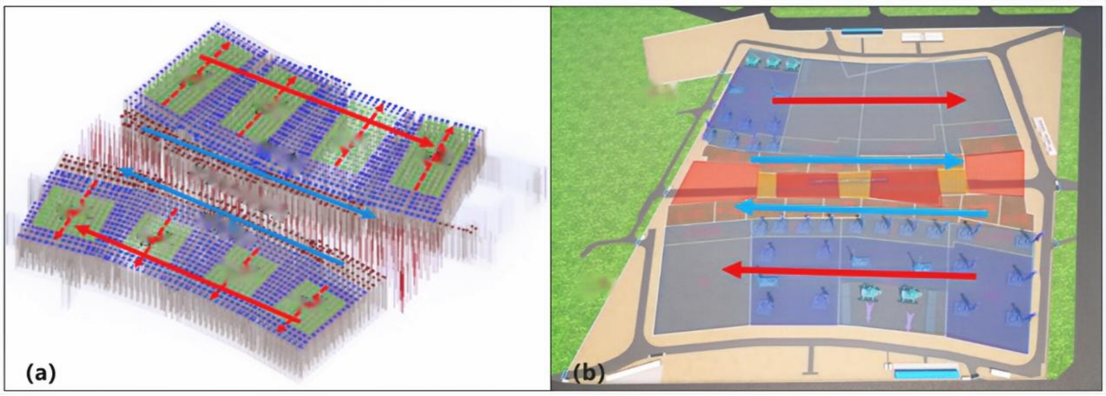

Figure 1 Symmetrical Reverse Construction Deployment of the Overall Pile Foundation

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.

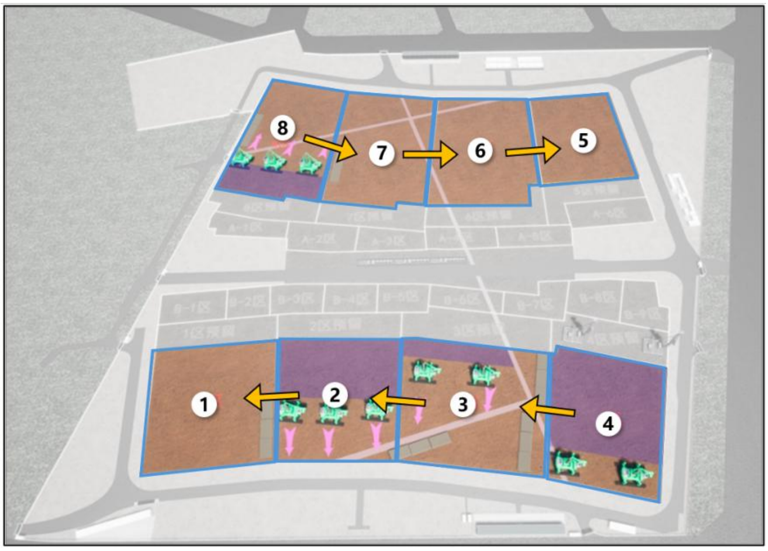

Figure 2 Pipe pile construction deployment in non-reserved area

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.

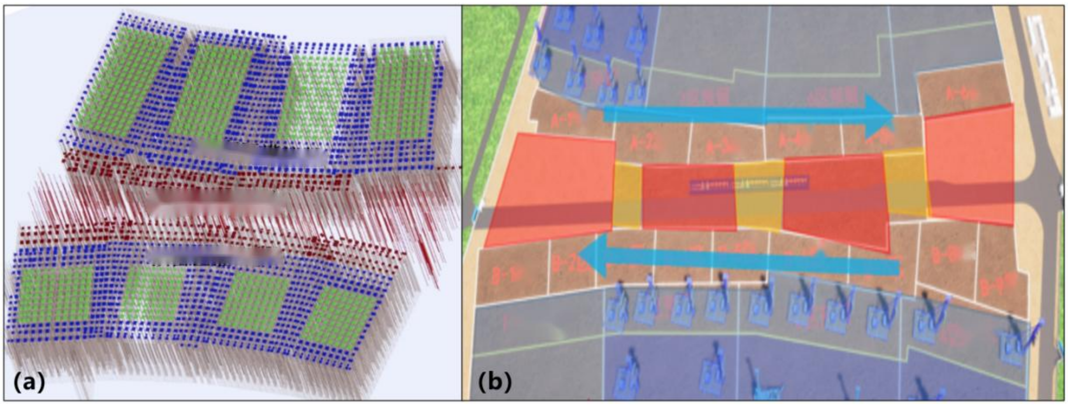

Figure 3 Construction deployment of cast-in-place piles in reserved area and ground protection area

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.

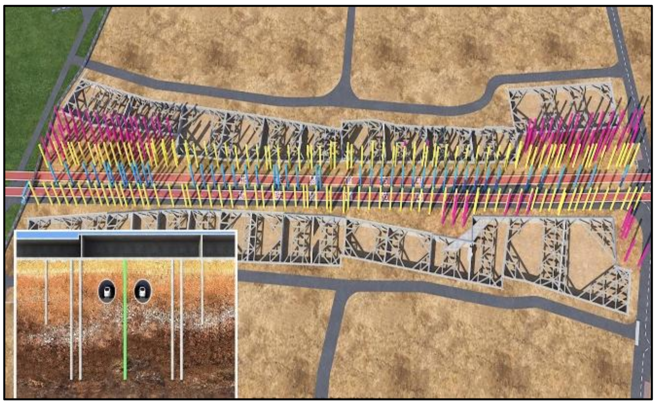

Figure 4 Construction deployment of cast-in-place piles in the central corridor

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.

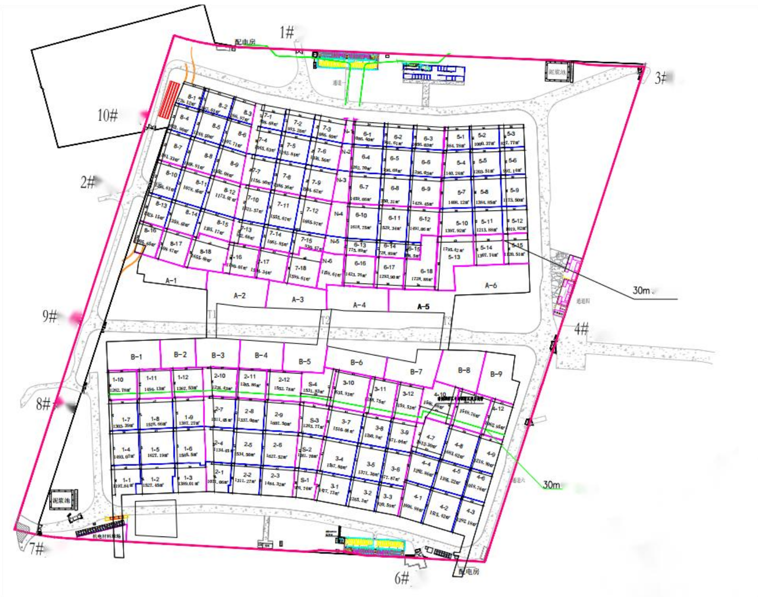

Figure 5 Partition Layout

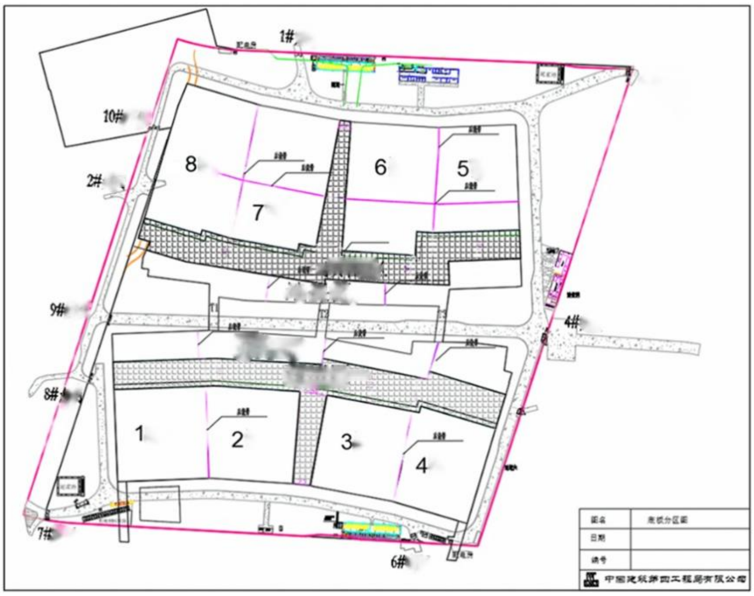

Figure 6 Plane Layout of Post-Casting Strip

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).

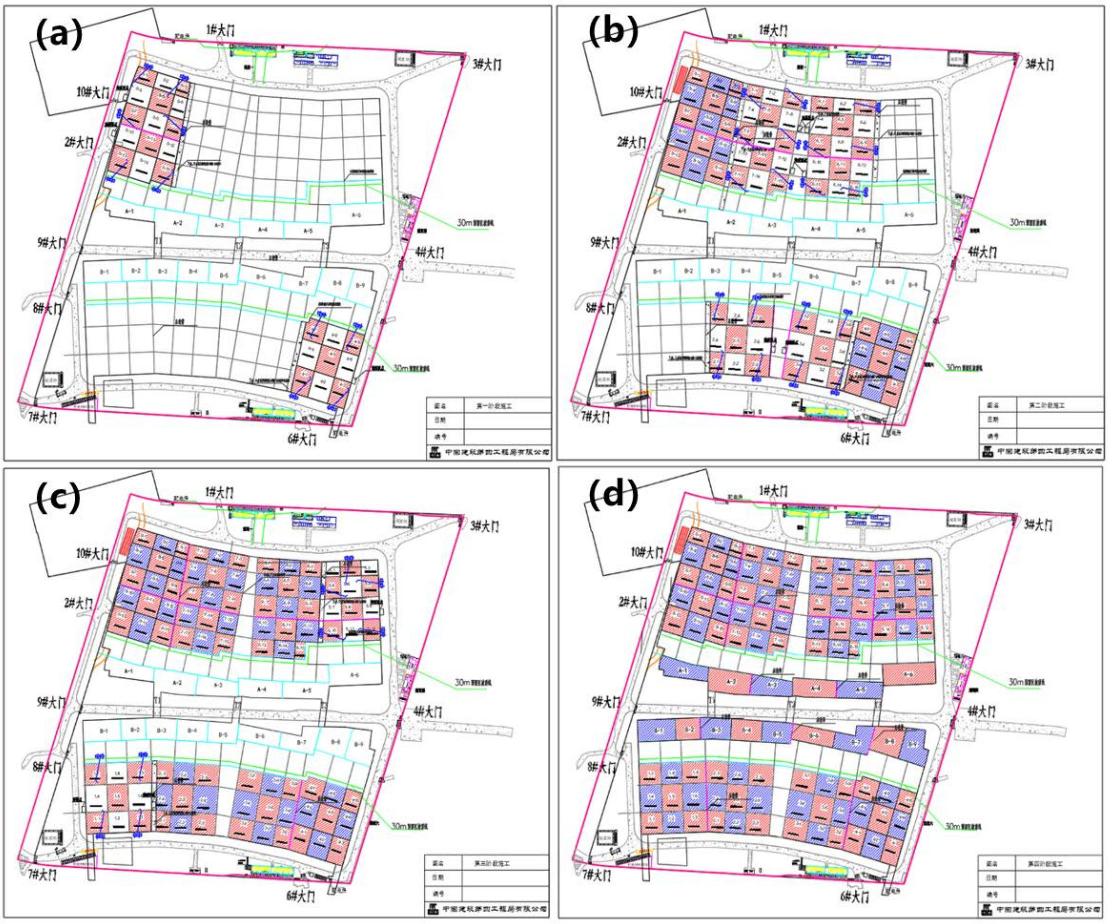

Figure 7 Phased Construction Deployment of Ultra-Large Area Base Plate

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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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajace3006

KEY CONSTRUCTION TECHNOLOGY OF SUPER-HIGH FISH-BELLY CABLE-POINT FOLDING CURTAIN WALL

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Abstract: With the development of urban construction, large public buildings have become the characteristic symbol of the city and the business card for external publicity. Public buildings with diverse appearances have become the norm in urban construction. Curtain walls are one of the most important forms of displaying the appearance of buildings. "High, large, special, new and difficult" curtain walls emerge in an endless stream, and various complex forms of curtain walls have become the difficulty of curtain wall construction. This paper introduces in detail the process methods of fish-belly steel truss installation, cable installation, broken line beam installation, and glass installation in the construction of ultra-high fish-belly cable-type glass curtain wall steel structure.
Keywords: Fish-belly; Cable; Broken line curtain wall

INTRODUCTION

The steel structure folded beams and fish-belly trusses of the fish-belly cable-type folded-line curtain wall are welded to further improve the lateral stiffness of the front chord of the fish-belly truss. The fish-belly cable-type glass curtain wall has high aesthetics and transparency. The combination of cables and fish-belly steel trusses provides a good view and lighting effect. However, since its construction process is different from that of conventional curtain walls, it has certain construction difficulties. This paper discusses the key construction technologies of super-high fish-belly cable-type folded-line curtain walls based on engineering examples [1-3].

1 PROJECT BACKGROUND

Take the curtain wall project of the east entrance hall of a certain project as an example. The curtain wall of the main entrance of the east entrance hall of this project is 83m wide and 36m high. The east facade adopts a fish-belly truss full-glass point-type tie-rod curtain wall in the form of a single-layer cable net structure. The cable is a stainless steel cable with a diameter of 22mm. The glass curtain wall adopts L0W-E tempered and glued hollow glass (4 pieces of ultra-white). The supporting system of the curtain wall is a fish-belly truss column. The upper and lower ends of the cable fixed ends and the cable adjustment ends are connected through the ear plates welded at the upper end. The cable is mainly divided into two sections, the upper section of the cable is fixed on the steel structure column at one end and fixed on the broken line beam at the lower end of the top glass; the upper end of the lower section of the cable is fixed on the lower end of the top glass. The glass installation order is from bottom to top. After each row of glass is installed, if the deviation is large, the crossbeam needs to be intervened by the cable to reset the crossbeam.

2 KEY TECHNOLOGIES

2.1 Construct BIM Model

Just like Figure 1, construct BIM model according to the drawings, use BIM technology to simulate construction and installation, and install keels and order glass curtain walls in strict accordance with theoretical dimensions by establishing BIM model. Combine Leica 3D scanner to scan the on-site steel structure, build the actual steel frame model, adjust and correct the existing BIM model, and absorb errors.

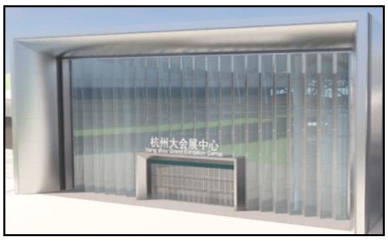

Figure 1 BIM Model

2.2 Measurement and Layout

Construction layout is mainly based on the ±0.000 elevation, building axis and curtain wall design drawings provided on site. All information must be complete. Structural inspection, after the support positioning line is drawn, vertical steel wires and horizontal lines are pulled at the structure as installation control lines. After measuring and laying out the actual exact position of the curtain wall structure, the position of all rods should be checked according to the tie rod support layout diagram. All measurement data must be reviewed. If the allowable error is exceeded, the cause should be found and corrected in time. Measurement and layout can be seen in Figure 2.

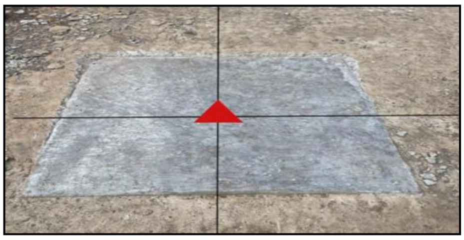

Figure 2 Measurement and layout

2.3 Installation of Fish-Belly Steel Trusses

The whole site adopts hoisting after assembly.In figure 3, the fish-belly trusses are divided into two sections, north and south, for construction. The 24.5m short truss on the upper side of the door head is reserved for final construction. The steel trusses on the north and south sides are constructed first. Two groups of personnel are used, each with a 200T crane + 80T crane + 1 38m aerial platform. After the construction is completed, one group of people is reserved for the construction of the four trusses above the door head. The hoisting position of the 200T crane avoids the central top plate and is selected at the natural ground position. The outriggers are laid with steel plates or sleepers depending on the hoisting situation.

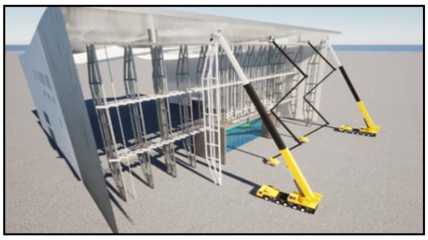

Figure 3 Installation of Fish-Belly Steel Trusses

2.4 Installation of Broken-Line Beams

This project has a total of 5 layers of broken-line beams. The stainless steel cables have only vertical locks. The locks are not connected to the glass, and only the broken-line steel beams of the glass are pulled. The cables are mainly divided into upper and lower sections. One end of the upper glass is fixed to the steel structure column, and the other end is fixed to the beam at the lower end of the top glass. The upper end of the lower cable is fixed to the lower beam of the top glass. Vertically downward, until the upper beam of the last glass ends.
Just like Figure 4, all cables can be installed in place before the glass is installed. The glass installation is divided into 5 areas, and the installation order is from bottom to top. After each row of glass is installed, the arch value of the beam needs to be compared to see if it is consistent with the design result. If the deviation is large, the beam needs to be intervened by the cable to reset the beam.

Figure 4 Installation of Broken Line Beams

2.5 Installation of Vertical Cables

This project is a single-layer cable net structure, with φ22 non-pressed cables used in both the horizontal and vertical directions, and the cable section A=286.37mm2. The top of the curtain wall support system is a fish-belly steel frame column, and the bottom is a box beam structure. The upper and lower cable fixed ends and cable adjustment ends are connected through the ear plates welded at the upper end. The installation sequence of the cable curtain wall cable is:

pre-calculate the deformation value of the beam and calculate the arch value of each cable point → install the beam in place according to the arch value → install the vertical cable → install the glass layer by layer in different areas → check whether the beam is reset.

Installation method of vertical cables: When installing cables, place the cable tray at the vertical position corresponding to each vertical cable, the cable corresponding to the upper steel beam, fix the winch clamp, tie the fixed end of the cable with a wire rope, and use the winch to lift the cable, that is, release it while installing the cable. When the fixed end is raised to about 1.5m away from the ear plate, use two 1.5T guide chains to fix the fixed end to the corresponding ear plate through the pin shaft; similarly, use two 1.5T guide chains to fix the adjustable end to the corresponding ear plate through the pin shaft. Other vertical cables are installed in this way.

2.6 Cable Prestressing

During the prestressing construction process, by monitoring the changes in structural deformation and cable force, the difference between the theoretical calculated value and the measured value can be found, and the calculation model can be corrected in time (if the difference is caused by the error of the calculation model), so as to ensure the correctness of the construction simulation calculation; ensure the safety and quality of the prestressing construction process, and make the final prestressed state consistent with the design requirements.

2.7 Installation of Folded Glass Curtain Wall

(1) The weight of a single piece of folded glass in the East Login Hall is about 1.7 tons, the highest point elevation is about 34m, there are 6 rows of glass on the facade, the height of the glass from the bottom to the top is 6m*5 rows + 5.5m*1 row, and the construction is carried out using 80T crane + ultra-high power electronic suction cup + 38m aerial platform.

(2) Before installation, check whether the size of the glass joint is consistent with the hole position of the joint claw. If it is not within the allowable difference range, it should be adjusted or processed.

(3) When the glass is installed in place, the ultra-high-power electronic suction cup slowly lifts the glass and places it in place on the beam.

2.8 Structural Monitoring

(1) Cable force monitoring. During the construction phase, cable force monitoring can be carried out through oil pressure sensors, dynamic measuring instruments or portable cable force measuring instruments. The cable force monitoring instrument can be selected according to the actual construction conditions. During the use phase, cable force monitoring can be carried out through pressure sensors, dynamic measuring instruments or portable cable force measuring instruments. The cable force monitoring instrument can be selected according to the actual conditions.

(2) Appearance inspection. The contents of the structural appearance inspection include: appearance inspection of cables, nodes, etc. and related surface paint inspections to ensure that various materials are safe and effective, the anti-corrosion meets the design requirements, and the structure is safe and reliable.

3 CONCLUSION

In summary, the functions of modern buildings are becoming increasingly complex. The fish-belly cable-type folded curtain wall is a new curtain wall support structure system with a transparent structure and greatly saves the space used for the support structure. After the construction of the super-high fish-belly cable-type folded curtain wall is completed, it has a good transparent effect, simple and bright, which adds a lot to the overall effect of the login hall and becomes a decorative highlight. It has been recognized by all sectors of society and has promotion value. Through the application of the fish-belly cable-type zigzag curtain wall construction method, good results have been achieved in terms of construction period, quality, safety, environment, etc., creating good economic benefits, social benefits, energy saving and environmental protection benefits, and has broad application prospects.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajace3003

KEY CONSTRUCTION TECHNOLOGY OF STONE-LIKE CONCRETE HANGING PANEL CURTAIN WALL

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Abstract: As an important building decoration material, concrete hanging board is widely used in modern building exterior wall decoration with its excellent physical properties and beautiful decorative effect. This paper aims to explore the key technologies in the construction of concrete hanging board, including material selection, prefabrication process, installation technology and quality control, so as to improve construction efficiency and project quality and ensure the beauty and durability of the building.
Keywords: Concrete hanging board; Construction technology; Prefabrication process; Installation technology; Quality control

INTRODUCTION

Concrete panels have gradually become the mainstream material for modern building exterior wall decoration due to their high strength, durability and diverse surface treatment effects. However, the construction technology of concrete panels is complex and involves multiple links. It must be carefully planned and implemented in terms of material selection, prefabrication, on-site installation and quality control to ensure the final project quality and decorative effect.

1 PREPARATION OF IMITATION STONE CONCRETE PANELS

The production process of this project is casting molding, and the production process flow is as follows Figure 1:

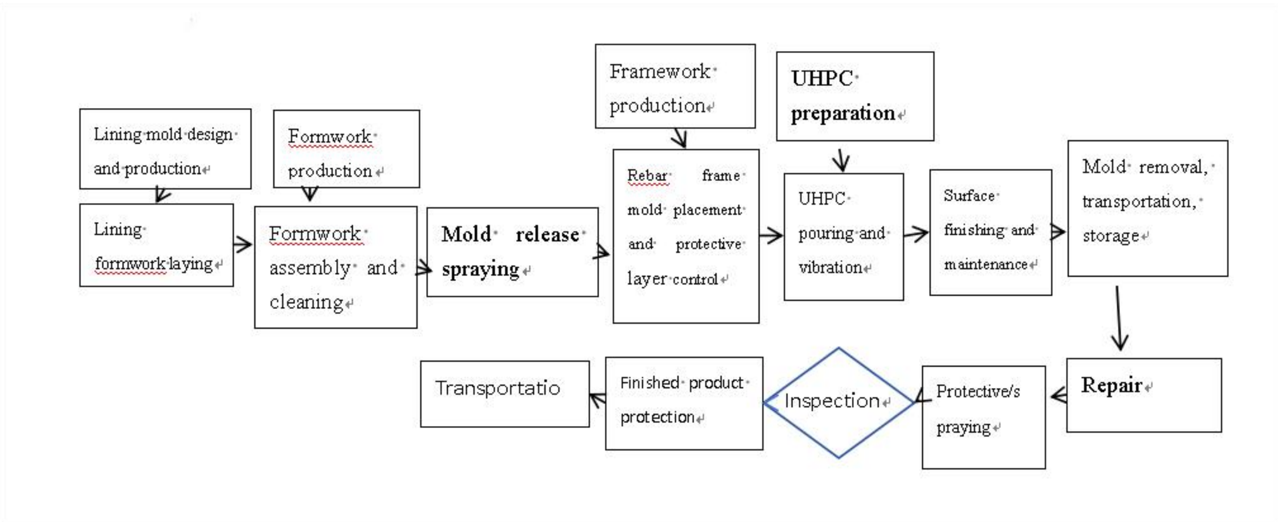


Figure 1 Production Process Flow Chart

1.1 Preparation before Production

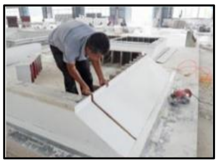
Prepare the necessary tools such as mud trowel, rubber bucket, water scoop, brush, electronic scale, hopper, slurry transport vehicle, etc.
Check whether the raw materials are complete and whether the measuring instruments are calibrated.
Check whether the mixing system is operating normally.
Check the mold and confirm whether it meets the requirements for starting work.
Check whether the embedded parts are installed properly, and whether the specifications, models and placement dimensions are consistent with the requirements of the drawings.

1.2 Mold Making

Flow chart of mold making process can be seen in Figure 2.


Mold carving


Mould making


Mold assembly


Mould putty scraping


Mold surface grinding

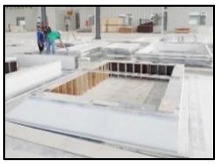

Mold Forming

Figure 2 Flow Chart of Mold Making Process

1.3 Casting process

1.3.1 Making UHPC casting material

1) Formula: Use Subot UHPC powder, supporting additives and fibers, etc.Casting material ratio values can been seen in Table 2.

Table 2 Casting Material Ratio Values

	Powder	water	Water reducing agent	fiber6mm	fiber12mm	Steel Fiber
Ingredients ratio	80	7.44	0.96	0.72	0.72	3.2
Quality Ratio	100	9.3	1.2	0.9	0.9	4
1cube（kg/m^3）	2093	194.6	25.12	18.84	18.84	83.72

2) Slurry mixing

Mix the weighed water (use ice water when the room temperature reaches above 25℃), water reducer and defoamer in a container. Turn on the mixer, add the weighed UHPC dry powder mixture into the mixer and stir, and start the timer at the same time. After the dry material is stirred for about 2 minutes, add water, water reducer and other mixtures at one time with the mixer turned on, and continue to stir until a uniform flowable state appears. This process takes about 5-6 minutes. Then sprinkle the weighed fiber with the mixer turned on. This process takes a long time to operate, so don't be anxious. The fiber must be spread evenly and there must be no fiber clumping. If the fiber is spread on the stirring wing during the fiber spreading process, notify the operator to stop the mixer, quickly scrape the fiber on the wing into the slurry, and then turn on the mixer to continue stirring until the fiber and slurry are fully mixed. This process takes about 6-8 minutes. Finally, stop the mixer to measure the material temperature and viscosity. The material temperature is tested using an inserted electronic thermometer and should be controlled within the range of 20-22°C in summer and autumn.Slurry mixing construction drawing can be seen in Figure 3.

Figure 3 Slurry Mixing Construction Drawing

1.3.2 Casting slurry

First, put the mixed slurry from the mixer into the special slurry transport hopper, then quickly transport the slurry to the production operation surface at the fastest speed and quickly pour the slurry into the mold. According to different mold shapes, first select the discharge position, open the discharge port under the hopper for rapid discharge. At the same time, the height between the discharge port and the mold surface should be controlled well, generally within the range of 500-600mm. After the entire product is cast, the operator should quickly wipe and clean the residual slurry on the mold surface. Finally, the quality personnel should check the size of the embedded parts and the overall thickness of the product. If any problems are found, notify the production operator in time to correct them to ensure that all parameters of the product are consistent with the requirements of the drawings.

1.5 Preliminary maintenance

After all the above work is completed, the wet curing agent should be sprayed on the back of the product immediately. The wet curing agent is diluted with propylene emulsion, and the dilution ratio is propylene emulsion: water = 1:3. When spraying, it is mainly on the visible surface of all products. Then cover with colored strips and plastic film for static curing.

1.4 Demolding

1.4.1 Demolding time

UHPC components can only be demolded when they reach a certain strength, so that they can have sufficient strength during demolding and transportation, and reduce the edge and corner damage caused by insufficient strength. Under normal circumstances, when the temperature is 20℃, UHPC components should be demolded after 12 hours.

1.4.2 Demolding method

When demolding, every detachable part of the mold should be removed, and large components should be assisted by a lifting device. The specific demolding method should be determined according to the shape of the mold in production. The demolding of the product can also be set up with necessary demolding hooks during product production as needed. If the steel frame is carried, the position of the demolding hanging point needs to be determined according to the engineer's advice.

After demolding is completed, check whether there are cracks at the demolding point (stress concentration area) and whether the embedded parts used to help demolding are loose. If there are these defects, they should be repaired in time.

1.5 Curing and Storage

After the product is demolded, it is placed on a special shelf and transported to the curing area for further curing.

2 INSTALLATION OF STONE-LIKE CONCRETE HANGING PANEL CURTAIN WALL

2.1 Construction Preparation

Before construction, a detailed site survey should be conducted to formulate a reasonable construction plan to ensure the completeness and safety of lifting equipment, scaffolding and other tools.

2.2 Installation and Fixing of Hanging Panels

2.2.1 Installation of supports and thermal insulation and waterproof materials

In figure 4 and 5, when hanging panels, the support system must be installed first. This support is a conventional screw form, which can achieve three-dimensional adjustment for the panel, and the operator can adjust it at the top. The site plans to use a boom truck to install the support and thermal insulation rock wool.

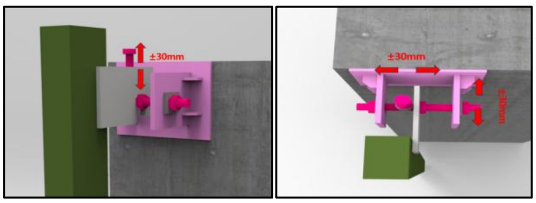


Figure 4 Three-dimensional Adjustment Display

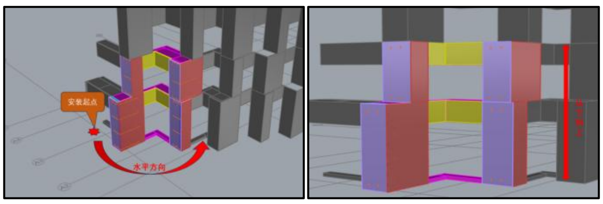


Figure 5 Schematic Diagram of the Installation Direction Sequence

2.2.2 Construction methods and measures for various types of panels

1) Installation steps for L-shaped panels, U-shaped panels, and beam side panels

① The tower crane/truck crane moves the panel to the target position 0.5m away from the structure.
② The operator hangs the manual hoist hook on the panel lifting point and tightens the steel cable. The hand chain hoist is fully stressed and releases the tower crane/truck crane rope.
③ The operator adjusts the hand chain hoist steel cable to connect the lower ear plate of the panel with the bracket hanger, and after accurately adjusting the position of the panel, locks the upper connection component.
④ The installation is completed.
Manual hoist installation can be seen in Figure 6 and Connection nodes of upper and lower parts of hanging board can be seen in Figure 7.

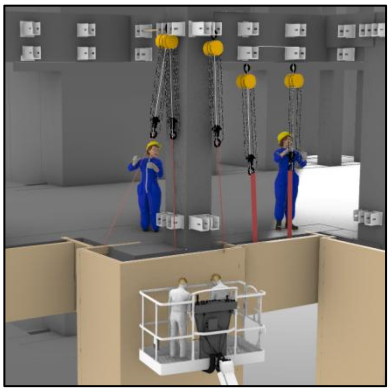


Figure 6 Manual Hoist Installation

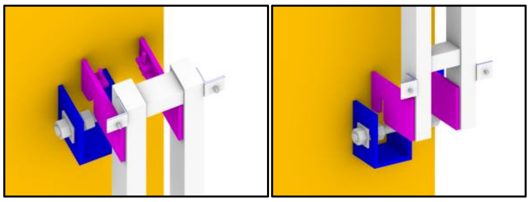


Figure 7 Connection Nodes of Upper and Lower Parts of Hanging Board

2) Column side plate installation steps
①Fix the fixture and column side plate firmly on the ground.
②The truck crane lifts the plate assembly to the target position.
③The operator adjusts the assembly to connect the lower ear plate of the plate with the bracket hanger, and after accurately adjusting the position of the plate, locks and installs the assembly.
④Installation completed
Measures: Truck crane, truck crane + fixture, straight arm truck
Assembly lifting can be seen in Figure 8.

Figure 8 Assembly Lifting

3) Installation steps of ceiling panels
① Use a construction hoist or tower crane/truck crane to transport the panels to the floor through the north and south window openings.
② Transfer the beam bottom plate to the platform and use a hydraulic forklift to lift the hanging plate to the target position at the bottom of the beam.
③ The operator connects the inner ear plate of the plate to the keel hanger and the outer connecting component locks.
④ Installation is completed.
4) Installation steps of beam cover plates and benches
① Use a construction hoist or tower crane/truck crane to transport the panels to the floor through the north and south

window openings.
② Use a hydraulic forklift to lift the hanging plate and transfer it to the target position on the top of the beam.
③ The operator locks the plate according to the specified node connection method.
④ Installation is completed.

3 QUALITY CONTROL

In order to strengthen the quality control of construction projects and clarify the focus of quality control at each construction stage, the quality of construction projects can be divided into three stages: pre-control, in-process control and post-control.

4 BENEFIT ANALYSIS

4.1 Environmental Benefits

① Saves natural stone and has no radioactivity
② Better thermal insulation properties

4.2 Social Benefits

The use of mature reinforced concrete structure for plate processing and installation connection is safer and more reliable than stone, and can make larger specifications and more shapes of plates, with good overall decorative effect and fewer joints.

5 SUMMARY

The construction technology of imitation stone concrete hanging board is complex, but as long as strict control is exercised in material selection, prefabrication process, installation technology and quality control, the decorative effect and durability of the hanging board can be ensured. By continuously summarizing and optimizing construction experience, the technical level and engineering quality of concrete hanging board construction can be further improved.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajace3004

STRESS ANALYSIS OF STONE-LIKE CONCRETE HANGING PANEL CURTAIN WALL

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Abstract: This paper mainly uses the stone-like concrete hanging board curtain wall system of a curtain wall project in Hangzhou to conduct stress analysis on the determined system, mainly making a detailed structural analysis of the stress condition of the main profile. On the premise of ensuring the facade effect and water tightness, it explores its stress distribution and deformation under various loads, tries to simplify the stress system, reduce the weight of the curtain wall, improve the installation accuracy, and shorten the unit assembly period.
Keywords: Construction engineering; Anti-stone concrete curtain wall; Finite element method

PREFACE

With the advancement of construction technology and the diversification of decorative materials, stone-like concrete hanging panels have gradually become one of the preferred materials for building curtain walls due to their unique aesthetic effects and superior physical properties. Imitation stone concrete hanging boards can not only simulate the appearance of natural stone, but also have the advantages of high strength, good durability, and low cost. However, due to its different material properties and construction techniques, its stress characteristics are significantly different from those of traditional stone curtain walls, so it is necessary to conduct a systematic stress analysis.
This article takes a large venue project in Hangzhou as an example to conduct stress analysis on the determined system. It mainly conducts a detailed structural analysis on the stress situation of the main profiles. On the premise of ensuring the facade effect and water tightness, it discusses Its stress distribution and deformation under various loads try to simplify the stress system, reduce the weight of the curtain wall, improve the installation accuracy, and shorten the unit assembly period.

1 PROJECT OVERVIEW

Taking a large venue in Hangzhou as an example, this project is a key project in Zhejiang Province, with a total land area of 49,900 square meters and a total construction area of 175,600 square meters, of which the above-ground construction area is approximately 107,700 square meters and the underground construction area is approximately 67,900 square meters. It includes a mountain-shaped tower and podium, with 2 floors underground and 15 floors above ground, with a total height of 73.5m. Among them, the outer facade of the gable-shaped tower is made of stone-like concrete hanging panel curtain wall, totaling 52,000 square meters, which is installed in a synchronous and staggered manner following the structural setback. Imitation stone concrete hanging board curtain wall can be seen in Figure 1.

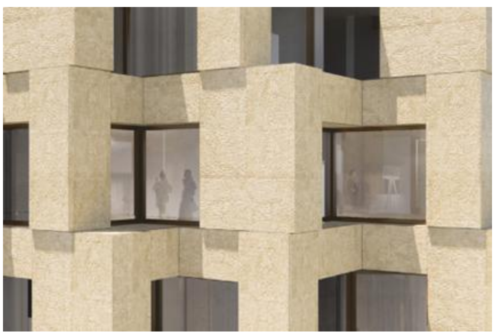

Figure 1 Imitation stone concrete hanging board curtain wall

Material characteristics of imitation stone concrete hanging board:
Imitation stone concrete hanging board is made of cement, sand, aggregate, admixture and appropriate fiber reinforcement material, and has the following characteristics: (1) High strength and durability: Imitation stone concrete material has high compressive and tensile strength and can withstand large external forces; (2) Light weight: Compared with natural stone, imitation stone concrete hanging board has a lighter weight, which is conducive to reducing the load

of the building; (3) Good weather resistance: The admixtures and reinforcing fibers added to the material make it have excellent weather resistance and can be used for a long time in various harsh environments.

2 STRESS ANALYSIS OF IMITATION STONE CONCRETE HANGING BOARD CURTAIN WALL

2.1 Stress Type

Imitation stone concrete hanging board curtain wall mainly bears the following loads:
Self-weight load: The weight of the hanging board itself is transmitted to the main body of the building through the supporting structure.
Wind load: The external wind pressure acts on the surface of the hanging board, generating positive and negative wind pressure effects.
Seismic load: Under the action of earthquake, the hanging board and its connecting parts need to withstand horizontal and vertical vibration and impact.
Temperature load: thermal expansion and contraction effect caused by changes in ambient temperature.

2.2 Force Model and Assumptions

In force analysis, it is usually assumed that the imitation stone concrete hanging board is a homogeneous, isotropic elastic material. The finite element method is used for simulation analysis to establish a force model of the hanging board under various loads. The deadweight, wind load, seismic load and temperature load of the hanging board are considered in the model.
Just like Figure 2, taking the highest 8-story slab in this project as an example, the 8-story L-shaped corner slab has a horizontal grid of 3165+1500mm and a height of 6135mm. According to the wind tunnel test report, the wind load here is +1.67kpa/-2.33kpa.

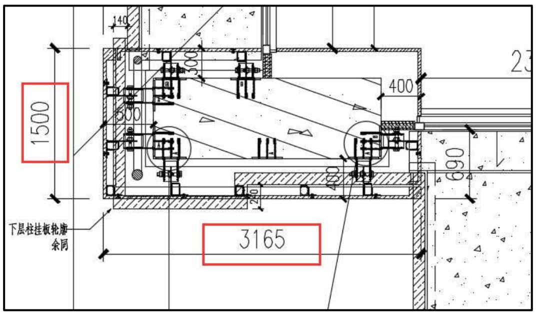

Figure 2 Plan of the highest plate on the 8th floor

3 CALCULATION METHOD

Finite element analysis of the hanging board was performed using ANSYS software. The specific steps are as follows:
1. Modeling: Establish a three-dimensional model based on the actual size and material properties of the hanging board.
2. Apply loads: Apply self-weight load, wind load, seismic load and temperature load respectively, and set reasonable boundary conditions.
3. Solution: Perform static and dynamic analysis to solve the stress distribution and deformation of the hanging board's bearing capacity, crack resistance and deflection under various loads.
4. Result analysis: Analyze the stress characteristics and weak links of the hanging board through stress cloud diagrams and deformation diagrams.

4 RESULTS AND DISCUSSION

4.1 Stress Conditions under Four Types of Wind Loads

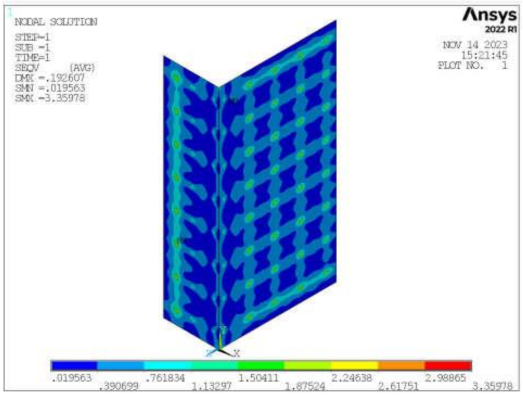

Figure 3. Plate Stress Cloud Diagram under Positive Wind Pressure on Both Sides

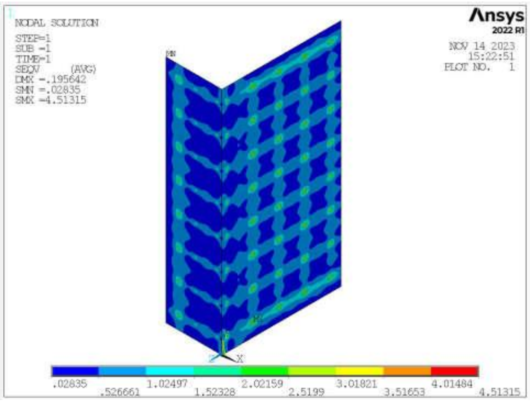

Figure 4 Plate Stress Cloud Diagram under One Positive and One Negative Wind Pressure

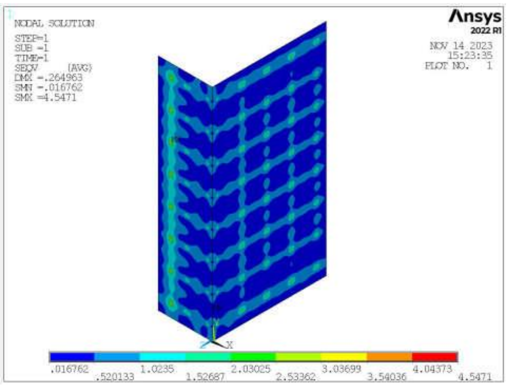

Figure 5 Plate Stress Cloud Diagram under One Negative and One Positive Wind Pressure

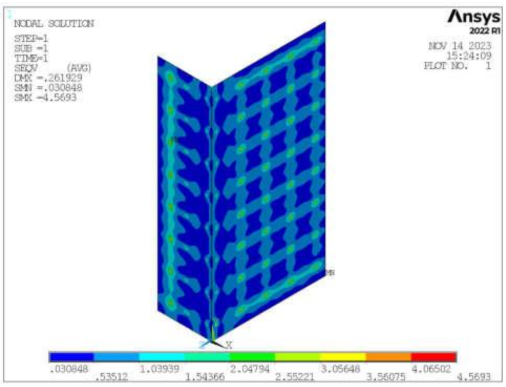

Figure 6 Plate Stress Cloud Diagram under Negative Wind Pressure on both Sides

In Figure 3-6, under the action of wind load, positive and negative wind pressures are generated on the surface of the hanging board, and the maximum stress is concentrated near the edge and fixing point of the hanging board. By strengthening the design of the fixing point and the edge part, the wind resistance of the hanging board can be effectively improved.

4.2 Stress Conditions of Crack Resistance Calculation

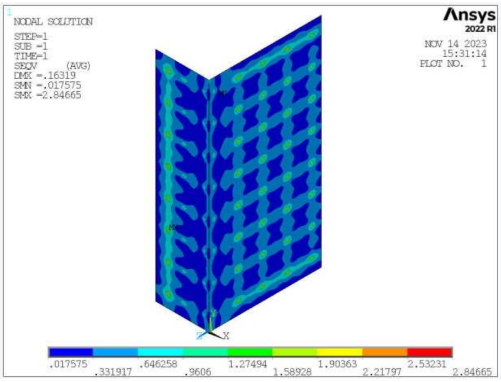

Figure 7 Panel Cross Section Cracking Stress Diagram

In Figure 7, the load causes the hanging board to vibrate in the horizontal and vertical directions, and the stress is concentrated at the connection part of the hanging board. By reasonably designing the connectors and supporting structures, the stress concentration caused by the load can be effectively reduced.

4.3 Stress Conditions of Deflection

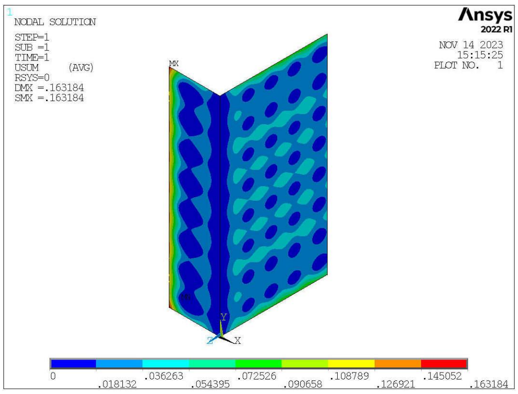

Figure 8 Panel Displacement Diagram

In Figure 8, the thermal expansion and contraction effect caused by the temperature load will cause a large deformation at the edge of the hanging board. By setting the expansion joint and the distance from the hanging board anchor point to the edge, the impact of temperature changes on the hanging board can be effectively alleviated.

5 CONCLUSION

(1) Superior material performance: The imitation stone concrete hanging board has high compressive strength and tensile strength, which can meet the requirements of the curtain wall system for bearing capacity. At the same time, its good weather resistance and durability enable it to maintain stable performance under various climatic conditions.
(2) Reasonable stress distribution: Through finite element analysis, it is found that the stress distribution of imitation stone concrete hanging panels under self-weight load, wind load, seismic load and temperature load is relatively uniform, and the local stress concentration phenomenon can be effectively alleviated through optimized design.
(3) The design of key parts is important: The fixing points and connectors of the hanging panels are the key parts of stress concentration. Reasonable design and installation can significantly improve the safety and stability of the system. The use of high-strength materials and flexible connection technology can effectively reduce stress concentration and fatigue damage.
(4) Strong environmental adaptability: Imitation stone concrete hanging panels show good adaptability under temperature changes and dynamic loads. Through reasonable structural design and construction technology, their durability and reliability can be further improved.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajace3007

STUDY ON THE MODIFICATION OF EARTH PRESSURE DISTRIBUTION PATTERN OF CIRCULAR WORKING SHAFT IN SOFT SOIL AREA

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Abstract: This article relies on actual engineering projects to conduct research on the earth pressure distribution model of circular working wells in soft soil areas. By establishing a well-soil three-dimensional numerical analysis model, the lateral displacement of the working well enclosure in the soft soil area is analyzed, and the earth pressure calculation method that considers the displacement effect is used to analyze the lateral earth pressure of the enclosure. On this basis, the influence of the working well space arch effect on the earth pressure distribution pattern under the conditions of wall insertion ratio, working well radius, wall thickness, wall elastic modulus and other factors was analyzed. Subsequently, based on the existing specifications, the soil pressure distribution model of circular working wells in soft soil areas was revised. The study shows that the radius of the working well has a significant impact on the earth pressure distribution pattern; in addition, the study obtained a fitting formula for the starting and ending depth and radius of the earth pressure reduction of the circular working well; and through comparative analysis, it was found that the use of considering the circular arch The effect-corrected earth pressure plane foundation beam method is simpler than the three-dimensional finite element method, has more mature parameter selection, and has lower calculation costs. Compared with the plane elastic foundation beam method of standardized earth pressure, it is closer to the actual displacement direction.
Keywords: Soft soil area; Circular working well; Spatial arch effect; Earth pressure distribution model

1 INTRODUCTION

Foundation pit engineering is a complex systematic project. The influence of many factors such as the stability of the supporting structure, the strength of the soil, the engineering environment and the seepage of groundwater has brought great challenges to the design and construction of foundation pit engineering. Tang Yeqing et al. [1] collected more than 160 cases of foundation pit engineering accidents. Most of the accidents were caused by inaccurate calculation of soil pressure. With the acceleration of urbanization in my country and the increasing development and utilization of underground space, the number of foundation pit projects is increasing. The circular foundation pit has the following two advantages: first, the retaining structure of the foundation pit will form a circular whole. This closed arch structure can make the retaining structure have the characteristics of circumferential compression, thereby giving full play to the high compressive strength of concrete materials [2]; second, the soil outside the circular foundation pit can produce an obvious "soil arch" effect, making the soil pressure acting on the circular support structure less than that of the straight-sided foundation pit. Therefore, more and more foundation pits are now using circular structure design [3]. At present, there are few literatures on the study of soil pressure in circular foundation pits. The research methods are mainly limited to the limit equilibrium method and the slip line method. The results obtained are only applicable to the ideal situation where the soil is uniform, the ground surface is horizontal, and the wall is vertical and smooth. Berezantzev[4] assumed that the hoop stress is equal to the first principal stress, derived the limit equilibrium differential equation under the three-dimensional axisymmetric case, and solved it using the slip line method, solving the problem of soil pressure in circular foundation pits under ideal conditions. Prater[5] summarized the limit equilibrium solution of active earth pressure in circular foundation pits, introduced the hoop stress coefficient, and analyzed its influence on soil pressure. The research results show that the soil pressure will decrease with the increase of the hoop stress coefficient, and it is recommended to take the hoop stress coefficient as the static earth pressure coefficient in actual calculations. Cheng et al.[6] introduced the hoop stress coefficient based on Prater's theory, assumed that the slip line is two sets of parallel straight lines, and solved the simplified slip line solution of the circular shaft soil pressure. They proposed that the result obtained by the Berezantzev solution, that is, when the hoop stress coefficient is 1.0, is too dangerous, and suggested that the hoop stress coefficient be taken according to the static soil pressure coefficient K0. Liu Faqian[7], based on the slip line theory, considered the influence of multiple factors such as the friction angle between the wall and the soil, the distribution of the pile load, the ground slope and the groundwater seepage on the soil pressure, and systematically studied the soil pressure acting on the circular foundation pit retaining structure; based on the limit analysis theory, the energy dissipation caused by the hoop compression of the soil was considered, and the upper limit solution of the active soil pressure of the circular foundation pit was derived, further developing the soil pressure theory. Zai Jinmin[8-10] et al. proposed a new method for calculating the soil pressure of the retaining wall. This method comprehensively considers the deformation of the wall and the change of the soil pressure. Lu Guosheng[11] et al. considered the influence of displacement when calculating the soil pressure, and compared the results with the finite element calculation results. Chen Yekai [12-14] used an exponential function to describe the relationship between the earth pressure acting on the retaining wall and the wall displacement, and calculated the earth pressure acting on the retaining wall under the non-limit state.

The theoretical research results of the earth pressure of circular foundation pits are still incomplete. The earth pressure results obtained based on the plane assumption do not consider the influence of factors such as the spatial effect of the soil and the curvature radius of the foundation pit. When the limit equilibrium method is used, the distribution form of the earth pressure cannot be obtained according to the static equilibrium of the sliding wedge. When the slip line method is used, it is necessary to properly describe the annular stress of the circular foundation pit, but the existing research results do not have a clear understanding of the annular stress of the soil around the circular foundation pit.

Based on the municipal comprehensive renovation project of Shanghai Hongqiao Business District, this paper intends to carry out a study on the earth pressure distribution pattern of circular working wells in soft soil areas. Based on the large-scale general finite element software Abaqus, a well-soil three-dimensional numerical analysis model is established. Considering factors such as wall insertion ratio, working well radius, wall thickness, and wall elastic modulus, the influence of the spatial arch effect of the working well on the earth pressure distribution pattern is explored. Based on the existing Shanghai Engineering Construction Code "Technical Code for Foundation Pit Engineering" [15], the soil pressure distribution model of circular working wells in soft soil areas is proposed and verified by combining engineering examples.

2 PROJECT OVERVIEW

The Shanghai Hongqiao Business District Municipal Comprehensive Renovation Project is located in a soft soil area and includes 2 working wells, 2 receiving wells and a water inlet gate well. Among them, the 4# working well is a circular structure with a diameter of 14m and a depth of 15m. It is a deep and large foundation pit with high requirements for its safety and stability. The outer side of the shaft is composed of a double-row bored cast-in-place pile water-stop curtain to form a retaining structure. The cast-in-place pile is 23m long and the wall is 1.5m thick. The working well is not supported and is constructed by layered reverse construction. The shaft excavation is divided into three steps. The specific construction conditions are shown in Table 1. The basic soil layer parameters are shown in Table 2.

Table 1 Construction Conditions

Working condition	Excavation depth and lining casting
Working condition 1	5m, casting lining within the depth range of 0-5m
Working condition 2	10m, casting lining within the depth range of 5-10m
Working condition 3	15m, casting lining and bottom plate within the depth range of 10-15m

Table 2 Basic Soil Layer Parameters

Serial number	Soil layer	thickness（m）	Severeγ（kN/m^3）	Initial porosity e_0	Cohesion c（kPa）	Poisson's ratio v
1	Clay soil	2.3	18.82	0.94	15	0.47
2	Silty clay soil	5.6	17.85	1.18	17	0.35
3	Silty clay soil	6.9	17.15	1.43	16	0.4
4	Brown clay soil	7.3	18.25	1.03	15	0.35
5	Green clay soil	1.8	19.8	0.71	15	0.3
6	Silty sand	21	19.25	0.76	6.7	0.3
7	Clay mixed with silty sand	33	18.45	0.94	-	0.61

3 THREE-DIMENSIONAL FINITE ELEMENT ANALYSIS MODEL OF WELL-SOIL INTERACTION

3.1 Finite Element Analysis Model

Based on the critical state theory and triaxial tests of weakly overconsolidated soil and normally consolidated soil, Roscoe et al. [16] of Cambridge University proposed the Cambridge model (CCM). Later, Roscoe et al. [17] modified the bullet-shaped yield surface of the Cambridge model and obtained the modified Cambridge model (MCC Model). The modified Cambridge model describes the elastic-plastic deformation characteristics of soil well both theoretically and experimentally, and is one of the most widely used soft soil constitutive models.

The modified Cambridge model requires four calculation parameters [17], namely the slope λ of the normal consolidation line in the v-lnp’ plane, the slope k of the rebound line in the v-lnp’ plane, the slope M of the CSL on the p’-q’ plane, and the Poisson’s ratio v. Among them, λ, k, and M can be obtained according to the following formula:

$$\lambda = \frac{C_c}{\ln 10} \quad (1)$$

$$k = \frac{C_s}{\ln 10} \quad (2)$$

$$M = \frac{6\sin\varphi'}{3-\sin\varphi'} \quad (3)$$

In the formula, C_C is the compression index of the soil, C_S is the rebound index of the soil, and φ' is the effective internal friction angle obtained from the triaxial compression test.

This paper adopts the Coulomb friction model with limited sliding to simulate the friction between the surrounding structure and the soil. In the Coulomb friction model, before starting to slide against each other, the two contact surfaces generate equivalent shear stress τ_{equal} on their interface:

$$\tau_{equal} = \sqrt{\tau_{FS1}^2 + \tau_{FS2}^2} \quad (4)$$

In the formula, τ_{FS1} is the shear (friction) stress in the 1st direction on the contact surface; τ_{FS2} is the shear (friction) stress in the 2nd direction on the contact surface.

The critical shear stress τ_{crit} is proportional to the normal contact stress P, as shown below:

$$\tau_{crit} = \mu P \quad (5)$$

In the formula, μ is the friction coefficient.

Setting the limit shear stress for the critical shear stress τ_{crit}, the critical shear stress can be expressed as:

$$\tau_{crit} = \min\,(\mu P,\ \tau_{max}) \quad (6)$$

Wherein, τ_{crit} is the limit shear stress. For the problem of the interaction between the underground continuous wall and the soil, τ_{max} is equivalent to the limit side friction resistance of the underground continuous wall.

When the equivalent shear stress τ_{equa}l on the contact surface exceeds the critical shear stress τ_{crit}, relative sliding begins to occur between the contact surfaces, as shown in Figure 1.

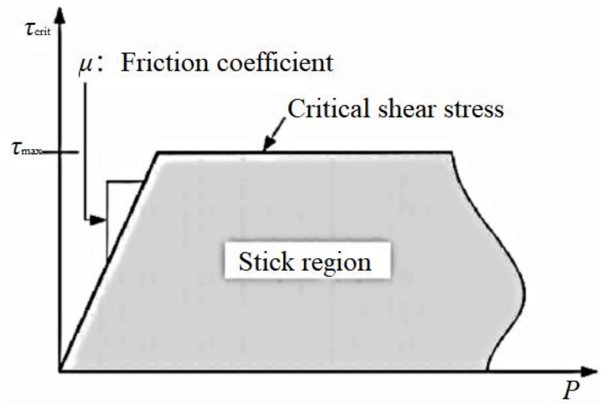


Figure 1 Coulomb Friction Characteristics [17]

Table 3 lists the basic calculation parameters of typical soil layers in soft soil areas, among which the effective internal friction angle φ', lateral pressure coefficient K0, compression curve slope λ, rebound curve slope k, critical state parameter M, and Young's modulus E can be obtained according to the above formula and relevant literature.

The contact surface parameters include the ultimate lateral friction resistance τ_{max} of the continuous wall and the wall-soil friction coefficient μ, among which τ_{max} refers to the standard value of the ultimate lateral friction resistance of cast-in-place piles in the "Geotechnical Engineering Investigation Code" [18], and the wall-soil friction coefficient μ refers to the recommended value of the friction coefficient between the pile foundation base and the foundation soil in the National Technical Code for Building Pile Foundations [19]. See Table 4 for details.

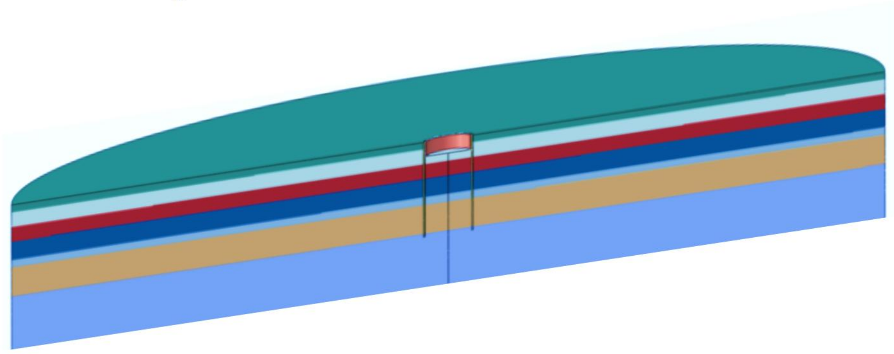
Table 3 Basic Calculation Parameters of Typical Soil Layers in Soft Soil Areas

Serial number	Effective internal friction angle ψ'(°)	Side pressure coefficient K_0[20]	Compression curve slope λ[21-22]	Rebound curve slope k[23]	Critical state parameters M	Young's modulus E (MPa) [24]
1	32	0.3	0.12	0.01	0.6	-
2	29	0.52	0.1	0.008	0.55	-
3	18	0.69	0.16	0.013	0.66	-
4	32	0.47	0.11	0.009	0.45	-
5	30	0.5	0.06	0.005	0.5	-
6	33	0.45	-	-	-	95
7	23	0.3	0.16	0.013	0.9	-

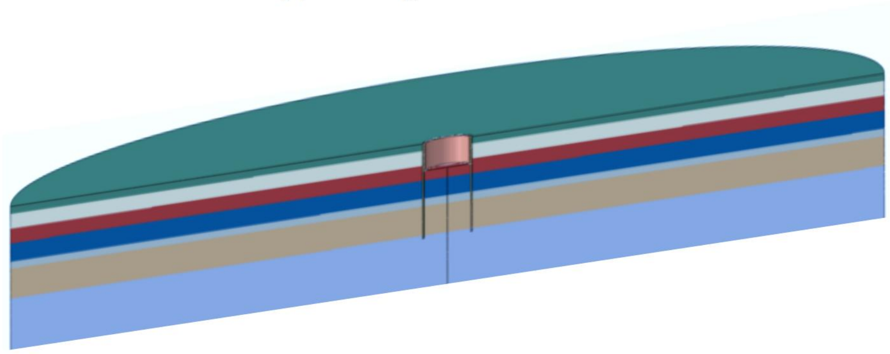
Table 4 Contact Surface Parameters of Each Soil Layer

Soil layer number / parameter	1	2	3	4	5	6	7
τ_{max} (kPa)	20	20	22	35	62	75	55
μ	0.3	0.25	0.25	0.35	0.3	0.4	0.35

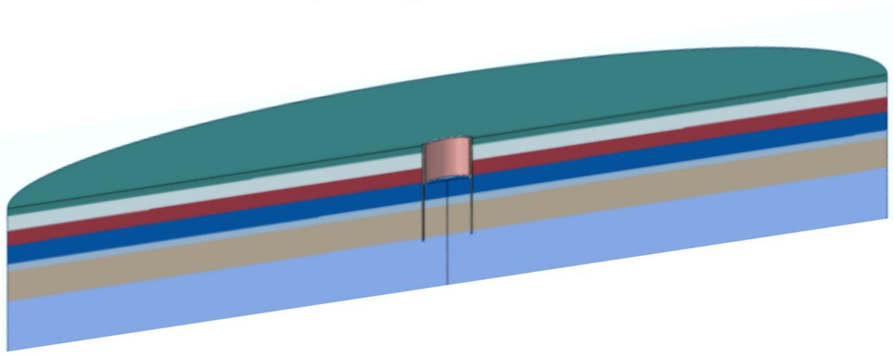
The thickness of the underground continuous wall is 1.8m, the thickness of the inner lining is 0.8m, the enclosure structure adopts a linear elastic model, the elastic modulus of the enclosure structure is based on the value of C30 concrete, that is, 3×10^{10}Pa, and the Poisson's ratio is 0.2. This paper uses the finite element software Abaqus to perform a three-dimensional finite element simulation of the circular shaft. Combined with the above working conditions, the simulation process is as follows Figure 2:



(a) Working condition 1 model



（b) Working condition 2 model



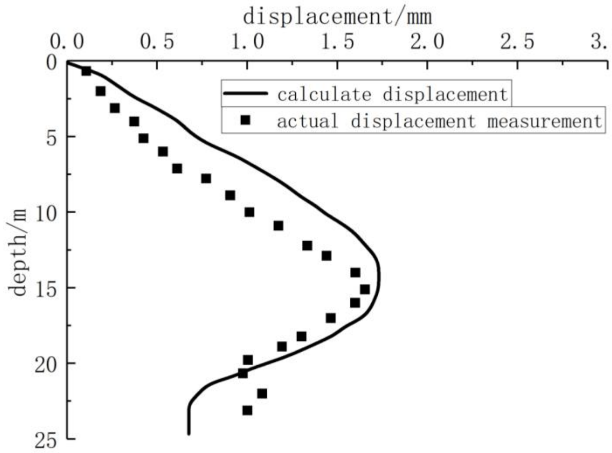
(c)Working condition three models

Figure 2 3D Finite Element Analysis Model of Circular Working Well

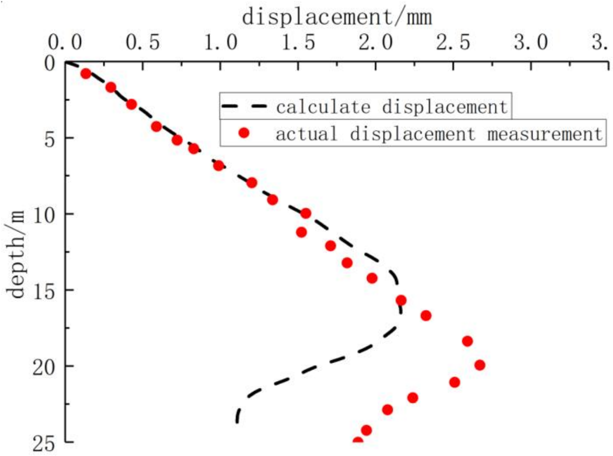
3.2 Analysis of Numerical Results

The calculation results and measured values of the lateral displacement of the retaining structure by three-dimensional finite element numerical simulation are shown in Figure 3. The results show that the maximum lateral displacement of the retaining structure at each excavation depth basically occurs near the excavation surface. As the excavation depth increases, the location where the maximum lateral displacement occurs also moves downward. The calculated maximum lateral displacement is consistent with the measured lateral displacement value. When the maximum excavation depth is reached, the calculated maximum lateral displacement value is 2.8 mm, and the measured maximum lateral displacement value is 3.0 mm. The ratio of the maximum lateral displacement of the wall to the excavation depth is about 0.02%, and the relative lateral displacement is small. The lateral displacement of the top and bottom of the wall is very small.

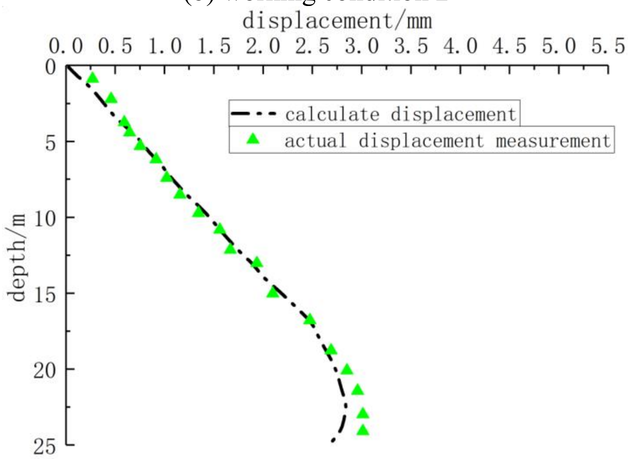
In this paper, referring to the distribution pattern of soil pressure in the Technical Code for Foundation Pit Engineering [15], the plane elastic foundation beam method considering the arch effect is used to carry out numerical simulation of the actual working condition, as shown in Figure 4. It can be seen that above the excavation surface, the lateral displacement of the retaining structure using the soil pressure distribution mode in the specification is basically consistent with the measured change trend, but there is a certain difference in the value; but below the excavation surface, the change trend of the two is different. The measured displacement value decreases with the increase of excavation depth, while the lateral displacement of the retaining structure calculated by the plane elastic foundation beam method of the soil pressure in the specification is basically unchanged below the excavation surface. There is a difference between the two, and the greater the depth, the more obvious the difference. This shows that the distribution mode of soil pressure in the existing specification cannot reflect the real deep soil pressure, and the calculation results have a certain deviation from the actual situation.



(a) working condition 1

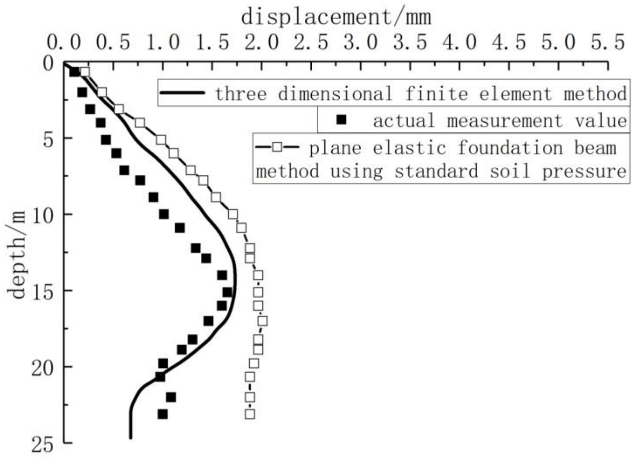


(b) working condition 2

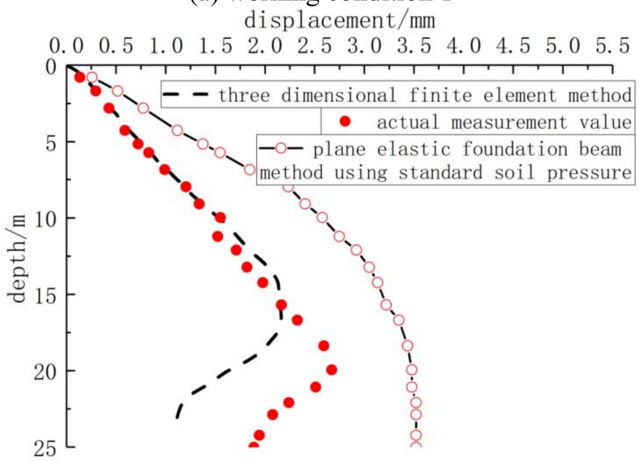


(c) working condition 3

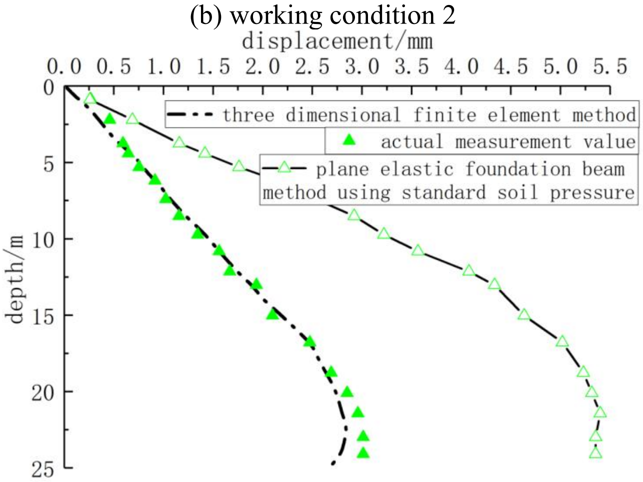
Figure 3 Comparison between Numerical Results and Measured Values of Lateral Displacement of Circular Working Pit Enclosure Structure



(a) working condition 1



(b) working condition 2



(c) working condition 3

Figure 4 Comparative Analysis of Lateral Displacement of Circular Working Pit Enclosure Structure

4 SOIL PRESSURE CALCULATION METHOD CONSIDERING DISPLACEMENT EFFECT

4.1 Soil Pressure Calculation Model

In order to fully consider the nonlinear relationship between soil pressure and displacement of enclosure structure, the passive side and active side soil pressure relationship are established respectively:

$$P_P = P_0 + (P_{Pcrit} - P_0)\left|\frac{\Xi}{\Xi_{Pcrit}}\right| e^{\xi\left|1-\frac{\Xi}{\Xi_{Pcrit}}\right|} \quad (7)$$

$$P_A = P_0 - (P_0 - P_{Acrit})\left|\frac{\Xi}{\Xi_{Acrit}}\right| e^{\xi'\left|1-\frac{\Xi}{\Xi_{Acrit}}\right|} \quad (8)$$

In the formula, P_P is the passive earth pressure; P_A is the active earth pressure; P_0 is the static earth pressure; P_{PC}rit is the passive earth pressure in the limit equilibrium state; P_{Acrit} is the active earth pressure in the limit equilibrium state; Ξ is the wall displacement; Ξ_{Pcrit} is the limit equilibrium displacement when the wall squeezes against the soil; Ξ_{Acrit} is the

limit equilibrium displacement when the wall leaves the soil; ξ, ξ' are parameters related to soil properties and other factors, $0 \le \xi \le 1$, $0 \le \xi' \le 1$.
Based on the above formula, when $\Xi=0$, $P_P=P_A=P_0$; when $\Xi=\Xi_{Pcrit}$, $P_P=P_{Pcrit}$; when $\Xi=\Xi_{Acrit}$, $P_A=P_{Acrit}$, that is, the boundary conditions are met.
For any given displacement, a secant line can be drawn through the corresponding point on the curve [14], and the earth pressure can be expressed as:

$$P_P = P_0 + \Lambda_P \cdot \xi \tag{9}$$

$$P_A = P_0 + \Lambda_A \cdot \xi \tag{10}$$

In the formula, ΛP is the foundation reaction coefficient in front of the wall; ΛA is the foundation reaction coefficient behind the wall.
Further, we can get:

$$\Lambda_{\mathrm{P}} = \frac{P_{Pcrit}-P_0}{\Xi_{Pcrit}} \cdot e^{\xi\left|1-\frac{\Xi}{\Xi_{Pcrit}}\right|} \tag{11}$$

$$\Lambda_{\mathrm{A}} = \frac{P_{Acrit}-P_0}{\Xi_{Acrit}} \cdot e^{\xi'\left|1-\frac{\Xi}{\Xi_{Acrit}}\right|} \tag{12}$$

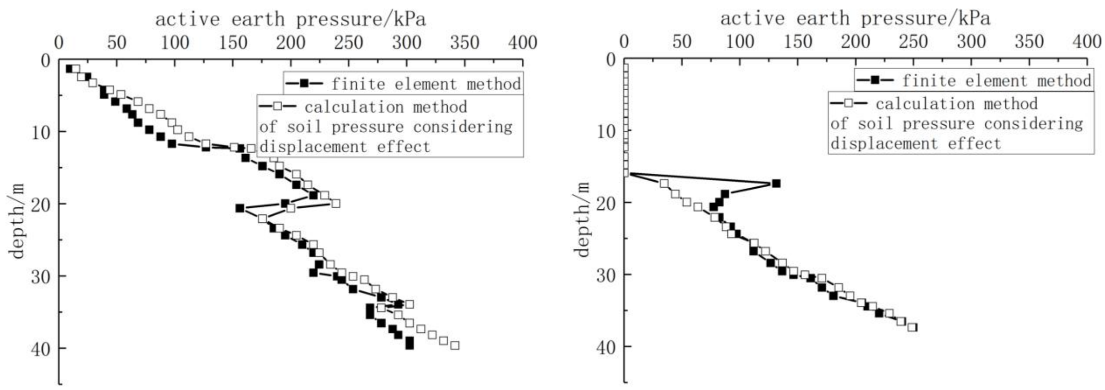
When ξ=0, ξ'=0, we can further obtain:

$$\Lambda_{\mathrm{P}} = \frac{P_{Pcrit}-P_0}{\Xi_{Pcrit}} \tag{13}$$

$$\Lambda_{\mathrm{A}} = \frac{P_{Acrit}-P_0}{\Xi_{Acrit}} \tag{14}$$

4.2 Analysis of Model Rationality

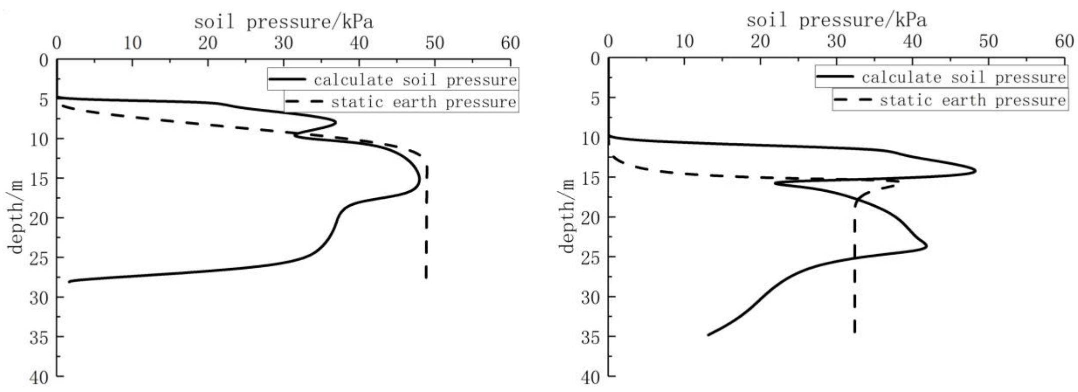
By comparing the soil pressure calculated by equations (7) and (8) with the three-dimensional finite element analysis model, it is found that the values and trends of the two are relatively consistent, which effectively verifies the feasibility of the three-dimensional finite element analysis model to calculate soil pressure and provides a reliable basis for subsequent research.



（a）active earth pressure （b）passive earth pressure

Figure 5 Earth Pressure Distribution of Circular Working Pit Excavation (15m)

In Figure 5, the soil pressure results for each working condition are shown in Figure 6. It is found that the distribution of soil pressure below the excavation surface does not follow the constant distribution pattern of the existing specifications, but starts to decrease from a certain depth. At a certain depth, the soil pressure can be regarded as zero, and the smaller the excavation depth, the more obvious this phenomenon is.



（a）excavation to a depth of 5m for soil pressure （b）excavation to a depth of 10m with soil pressure increment increment

Figure 6 Soil Pressure Increment under Different Working Conditions of Circular Working Well

5 INFLUENCE OF SPATIAL ARCH EFFECT OF WORKING WELL ON SOIL PRESSURE DISTRIBUTION PATTERN

Based on the well-soil three-dimensional numerical analysis model, factors such as wall insertion ratio, working well radius, wall thickness, and wall stiffness are considered to explore the influence of spatial arch effect of working well on soil pressure distribution pattern.

5.1 Influence of Wall Insertion Ratio

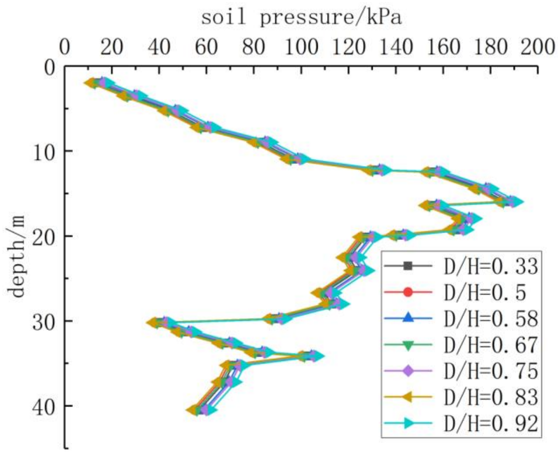


Figure 7 Lateral Earth Pressure of Working Shaft under Different Insertion Ratios (Excavation Depth 15m)

Figure 7 shows the relationship between the lateral earth pressure of working shaft and depth when the wall insertion ratio is 0.33, 0.5, 0.58, 0.67, 0.75, 0.83, and 0.92 respectively under the premise of excavation depth 15m. It can be found that when the wall insertion ratio is changed, the change trend of the lateral earth pressure of circular shaft along the depth direction is basically the same. In other words, the size of the wall insertion ratio has little effect on the distribution pattern of lateral earth pressure of circular shaft.

5.2 Influence of Working Shaft Radius

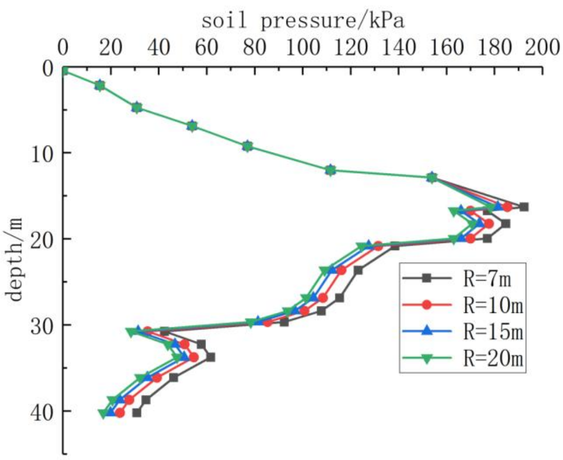


Figure 8 Lateral Earth Pressure of Working Shaft under Different Radius Conditions (Excavation Depth 15m)

Figure 8 shows the relationship between the lateral earth pressure and depth when the working shaft radius is 7m, 10m, 15m, and 20m respectively under the premise of excavation depth 15m. As can be seen from the figure, when the radius of the working well is changed, the change trend of the lateral earth pressure along the depth direction is basically the same, and the values above the excavation surface are basically the same; but there are certain differences in the values below the excavation surface. As the radius increases, the earth pressure tends to decrease. In other words, the radius of the working well has a more prominent effect on the distribution pattern of the lateral earth pressure, and as the radius increases, the spatial arch effect becomes less obvious.

5.3 Influence of Wall Thickness

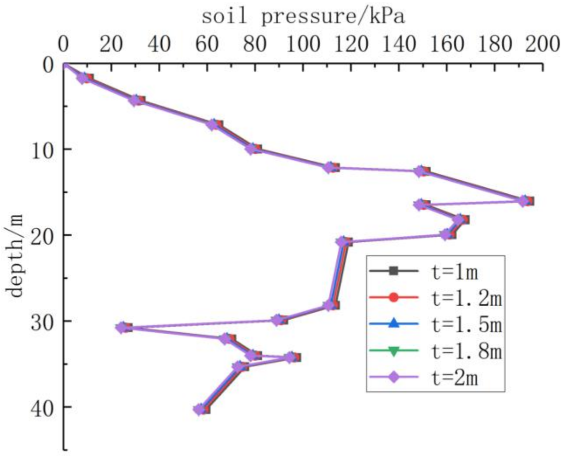


Figure 9 Lateral Earth Pressure of the Working well under Different Wall Thickness Conditions (Excavation Depth 15m)

Figure 9 shows the relationship between the lateral earth pressure of the circular working well and the depth when the thickness of the underground continuous wall is 1m, 1.2m, 1.5m, 1.8m, and 2m respectively. The results show that when the wall thickness is changed, the change trend of the circular shaft earth pressure along the depth direction is basically the same, and the thickness change has little effect on the distribution pattern of the circular shaft earth pressure.

5.4 Influence of Wall Elastic Modulus

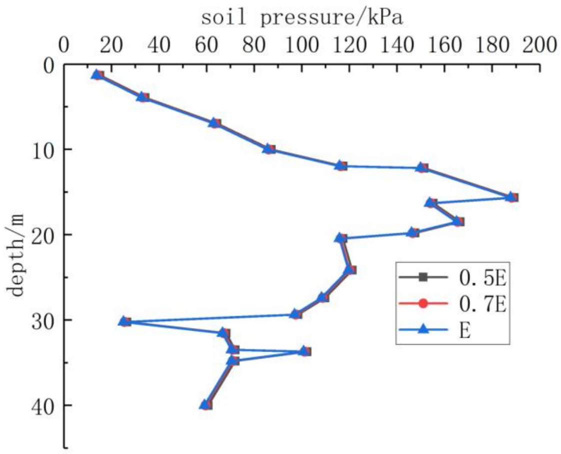


Figure 10. Lateral Earth Pressure of Working Shaft under Different Wall Elastic Modulus Conditions (Excavation Depth 15m)

Figure 10 shows the relationship between the lateral earth pressure of circular working shaft and depth when the elastic modulus of underground continuous wall is 0.5E, 0.7E, and E respectively. The results show that when the elastic modulus of the wall is changed, the earth pressure of the circular shaft also shows the same trend along the depth direction, and the value is almost unchanged.

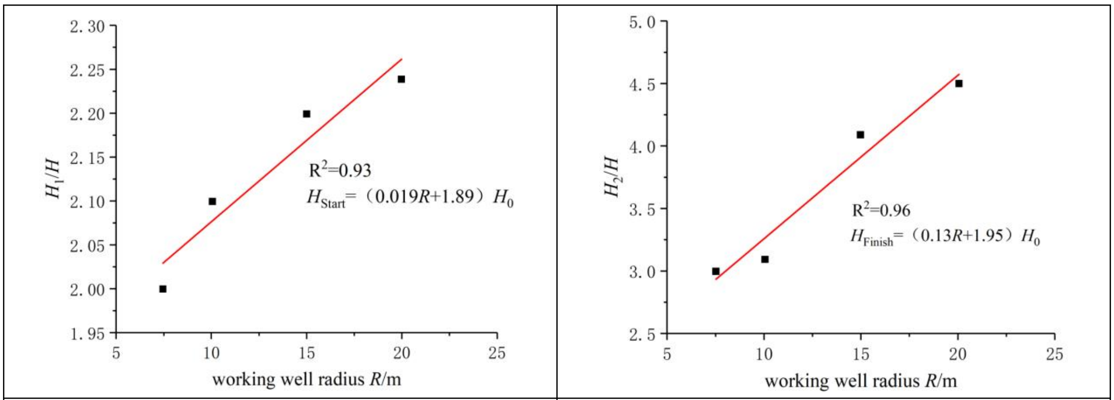
6 CORRECTION OF EARTH PRESSURE MODEL OF CIRCULAR WORKING SHAFT IN SOFT SOIL AREA

6.1 Correction of Earth Pressure Distribution Model

Furthermore, the earth pressure distribution model of circular working shaft in soft soil area is studied by taking the working shaft radius as the main research factor. In view of the analysis conclusions in Section 3, the earth pressure distribution model in the existing specification [15] cannot reflect the real deep earth pressure. Therefore, it is corrected on its basis and the earth pressure distribution model of circular shaft in soft soil area is proposed. For circular working wells in soft soil areas, the distribution of soil pressure above the excavation surface is basically consistent with the distribution pattern of existing specifications; the soil pressure below the excavation surface starts to decrease from a certain depth (point A) and at a certain depth (point B), the soil pressure can be regarded as zero, and the soil pressure in the AB section is reduced linearly. The relationship between the depth of the starting point (point A) and the depth of the end point (point B) of the working wells with different radii below the excavation surface and the excavation depth and the fitting curve are shown in the figure 11 below, and the fitting formulas are obtained respectively:

$$H_{\text{Start}} = (0.019R + 1.89) \cdot H_0 \tag{15}$$

$$H_{Finish} = (0.13R + 1.95) \cdot H_0 \tag{16}$$



（a）starting depth of soil pressure reduction　（b）end depth of soil pressure reduction

Figure 11 Relationship between the Starting and End Depths of Soil Pressure Reduction in Circular Working Wells and Radius

6.2 Example Demonstration of Circular Working Wells

The actual size of the 4# circular working well in the municipal comprehensive renovation project of Shanghai Hongqiao Business District is combined with the above fitting formula to obtain the starting and end depths of soil pressure reduction, see Table 5. As shown in Figure 12, the maximum lateral displacement of the retaining structure calculated by the plane elastic foundation beam method with the modified earth pressure distribution mode is 2.0mm, which is close to the measured value of 1.7mm, 1.8mm obtained by the three-dimensional finite element method, and 2.1mm obtained by the plane elastic foundation beam method with the standard earth pressure distribution mode. However, the plane elastic foundation beam method with the modified earth pressure distribution mode is simpler to model, has more mature parameter selection, and lower calculation cost than the three-dimensional finite element method. Compared with the plane elastic foundation beam method with the standard earth pressure distribution mode, it is closer to the actual displacement trend.

Table 5 Starting and Ending Depths of Soil Pressure Reduction

Excavation depth H_0（m）	Starting depth of soil pressure reduction H_{Start}（m）	End depth of soil pressure reduction H_{Finish}（m）
5	10.1	14.3
10	20.2	23（bottom of wall）
15	23（bottom of wall）	23（bottom of wall）

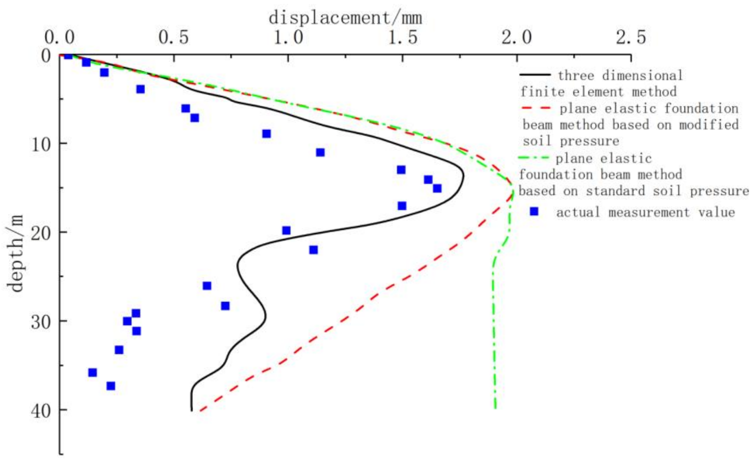


Figure 12 Comparison of Calculated and Measured Lateral Displacements of Circular Working Well Enclosure Structure

7 CONCLUSION

Based on the municipal comprehensive renovation project of Shanghai Hongqiao Business District, this paper studies the soil pressure distribution pattern of circular working well in soft soil area. Based on the large-scale general finite element software Abaqus, a three-dimensional numerical analysis model of well-soil is established. Factors such as wall insertion ratio, working well radius, wall thickness, and wall elastic modulus are considered to explore the influence of the spatial arch effect of the working well on the soil pressure distribution pattern. Based on the existing specifications [15], the soil pressure distribution pattern of circular working well in soft soil area is proposed and verified by combining engineering examples. The main conclusions are as follows:

(1) Combined with the measured values, the three-dimensional numerical analysis model used in this paper can better reflect the changing trend, maximum value and corresponding position of the lateral displacement of the circular working well enclosure structure. However, the soil pressure distribution pattern in the existing specifications cannot reflect the real deep soil pressure, and there is a certain deviation between the calculation results and the actual situation.

(2) By exploring the influence of the spatial arch effect of the working well on the soil pressure distribution pattern under different influencing factors, it is found that the radius of the working well has a significant effect on it, while the wall insertion ratio, wall thickness and wall elastic modulus have little effect on it.

(3) By making corrections based on the existing specifications, the soil pressure distribution pattern of the circular working well in soft soil areas is proposed, and the fitting formula of the starting and ending depth and radius of the circular working well soil pressure reduction is obtained.

(4) By comparison, it is found that the modified earth pressure plane foundation beam method considering the circular arch effect is simpler than the three-dimensional finite element method, the parameter selection is more mature, and the calculation cost is lower. Compared with the plane elastic foundation beam method of the earth pressure in the specification, it is closer to the actual displacement trend.

COMPETING INTERESTS

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

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Academic Journal of Architecture and Civil Engineering
ISSN: 2960-0243
DOI: 10.61784/ajace3008

THE IMPACT OF ENVIRONMENTAL STRESSORS ON SUBJECTIVE WELL-BEING: AIR QUALITY, NOISE, AND URBAN HEAT

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Abstract: This paper examines the impact of environmental stressors—specifically air quality, noise pollution, and urban heat—on the subjective well-being of urban residents. As urbanization and industrial growth intensify, these stressors have become increasingly significant in shaping the quality of life within cities. The study synthesizes existing literature and empirical findings to highlight how poor air quality, chronic noise exposure, and rising urban temperatures adversely affect mental health, life satisfaction, and emotional well-being. The findings reveal that individuals living in areas with high levels of air pollution experience increased rates of anxiety and depression, while noise pollution contributes to stress, sleep disturbances, and cognitive impairments. Additionally, urban heat exacerbates discomfort and social isolation, particularly among vulnerable populations. The paper emphasizes the need for integrated urban planning and public health strategies that prioritize environmental quality to enhance the overall well-being of city dwellers. By fostering community engagement and implementing effective interventions, cities can mitigate the adverse effects of these environmental stressors and promote healthier, more resilient urban environments.
Keywords: Environmental stressors; Subjective well-being; Urban health

1 INTRODUCTION

In the context of rapid urbanization and industrial growth, environmental stressors such as air pollution, noise, and urban heat have become increasingly prominent in shaping the quality of life for urban residents [1]. These stressors not only pose direct threats to physical health but also significantly impact subjective well-being－the self-reported assessment of life satisfaction and emotional experiences. Subjective well-being is a crucial component of public health, influencing social cohesion, productivity, and overall community resilience. As cities expand and populations grow, understanding the interplay between environmental factors and subjective well-being becomes essential for fostering healthier urban environments [2].
Air quality has emerged as a critical determinant of health and well-being, with numerous studies linking exposure to pollutants such as particulate matter (PM), nitrogen dioxide (NO2), and sulfur dioxide (SO2) to adverse health outcomes, including respiratory and cardiovascular diseases [3]. The World Health Organization (WHO) has identified air pollution as one of the leading environmental health risks, contributing to millions of premature deaths annually. Furthermore, the psychological implications of poor air quality are becoming increasingly evident, with research indicating associations between air pollution and increased rates of anxiety, depression, and decreased life satisfaction [4]. The pervasive nature of air pollution in urban settings necessitates a deeper understanding of its broader impacts on mental health and well-being [5].
Noise pollution, another pervasive environmental stressor, has been shown to affect mental health and well-being. Chronic exposure to high levels of noise, particularly in urban settings, has been linked to increased stress, sleep disturbances, and cognitive impairments[6]. The impact of noise on subjective well-being is profound, as it can lead to decreased quality of life and heightened feelings of discomfort and dissatisfaction[7]. Noise can disrupt daily activities, impair communication, and contribute to a sense of urban chaos, further exacerbating the challenges faced by city dwellers. Understanding how noise pollution interacts with other environmental stressors is critical for developing effective interventions aimed at improving life quality in urban areas [8].
Urban heat, exacerbated by the urban heat island effect, presents additional challenges to residents' well-being [9]. Higher temperatures in urban areas not only contribute to physical health risks, such as heat-related illnesses, but also affect mental health by increasing discomfort and stress levels [10]. The urban heat island effect, which results from human activities and modifications to the natural landscape, can lead to temperature differences of several degrees between urban and rural areas. Vulnerable populations, including the elderly and those with pre-existing health conditions, are particularly affected by the compounded effects of heat, pollution, and noise [11]. These populations may experience heightened vulnerability to heat stress, exacerbating existing health disparities.
This paper aims to systematically examine the impact of these environmental stressors－air quality, noise, and urban heat－on residents' subjective well-being. By reviewing existing literature and empirical studies, this research will provide a comprehensive understanding of how these factors interact to influence quality of life [12]. Additionally, the paper will explore potential pathways through which environmental stressors affect mental health, including

physiological responses, behavioral changes, and social dynamics. Ultimately, the findings will inform urban planning and public health strategies aimed at mitigating the adverse effects of environmental stressors and enhancing the well-being of urban populations. By addressing these critical issues, this research seeks to contribute to the development of healthier, more sustainable urban environments that promote the well-being of all residents.

2 LITERATURE REVIEW

The literature on the impact of environmental stressors on subjective well-being is extensive and multifaceted. Studies have consistently demonstrated that poor air quality has detrimental effects on both physical and mental health [13-17]. For example, David found that children living in areas with high levels of air pollution exhibited lower cognitive performance and increased behavioral problems [18]. Chen reported that long-term exposure to PM2.5 was associated with higher rates of anxiety and depression among adults [19]. The evidence suggests that air pollution not only affects respiratory and cardiovascular health but also has far-reaching implications for mental health and cognitive functioning[20-22].

The psychological implications of air pollution extend beyond direct health effects. Research by Clark revealed that individuals living in polluted areas often report lower life satisfaction and higher stress levels [23]. Power highlighted the role of air quality in shaping emotional well-being, noting that even short-term exposure to pollutants can lead to increased feelings of anxiety and irritability [24-28]. These findings underscore the need for public health interventions that address air quality as a means of improving mental health outcomes.

Noise pollution is another critical environmental stressor that has been linked to subjective well-being. A meta-analysis by Stansfeld and Matheson concluded that chronic noise exposure is associated with increased psychological distress and decreased quality of life[29-33]. Basner further emphasized the negative effects of noise on sleep quality and cognitive functioning, which can compound the overall impact on well-being[34]. Miedema and Vos found that residents living near airports or major roadways reported significantly lower levels of life satisfaction, underscoring the importance of noise regulation in urban planning[35]. The cumulative effects of noise exposure can lead to chronic stress, which has been shown to have long-term implications for mental health.

Urban heat, particularly in the context of the urban heat island effect, has received increasing attention in recent years. Stone demonstrated that urban heat exacerbates health risks, particularly during heat waves, leading to increased mortality and morbidity rates[36]. Harlan highlighted the psychological impacts of heat, noting that elevated temperatures can lead to increased aggression and irritability, thereby affecting interpersonal relationships and community cohesion[37-40]. The psychological stress associated with extreme heat events can also contribute to social unrest and decreased community resilience.

The interplay between these environmental stressors complicates the relationship between urban living and subjective well-being. For instance, Ostro found that the combined effects of heat and air pollution significantly increased the risk of heat-related illnesses and psychological distress[41]. Kloog further illustrated how urban heat exacerbates the effects of air quality issues, particularly for vulnerable populations[42]. The interactions between these stressors can create a feedback loop, where worsening conditions lead to declining mental health, which in turn may exacerbate the impacts of environmental stressors.

Despite the growing body of literature, gaps remain in understanding the cumulative effects of these environmental stressors on subjective well-being. Future research should explore the potential mitigating factors, such as access to green spaces, community engagement, and socioeconomic status, which may buffer the adverse impacts of environmental stressors[43-45]. Green spaces, in particular, have been shown to promote mental health and well-being by providing opportunities for recreation, social interaction, and relaxation. Furthermore, interdisciplinary approaches that integrate environmental science, psychology, and public health will be essential for developing effective strategies to enhance urban residents' quality of life[46]. By addressing the complex interactions between environmental stressors and subjective well-being, researchers and policymakers can work towards creating healthier, more resilient urban environments that prioritize the mental health and well-being of all residents.

In summary, the existing literature underscores the critical need to address environmental stressors as integral components of public health policy. The evidence suggests that improving air quality, reducing noise pollution, and mitigating urban heat can lead to significant improvements in subjective well-being, ultimately contributing to healthier, more sustainable urban communities. As urbanization continues to accelerate globally, understanding and addressing these environmental challenges will be paramount in promoting the health and well-being of urban populations.

3 METHODOLOGY

3.1 Research Design

This study employs a mixed-methods research design, integrating quantitative and qualitative approaches to comprehensively assess the impact of environmental stressors—air quality, noise, and urban heat—on subjective well-being. The quantitative component involves statistical analysis of survey data collected from urban residents, while the qualitative aspect includes in-depth interviews and focus groups to capture personal experiences and perceptions related to environmental stressors.

3.2 Sample Selection

A stratified random sampling method will be used to select participants from various urban neighborhoods characterized by differing levels of environmental stressors. The sample will include individuals aged 18 and older, ensuring a diverse representation in terms of age, gender, socioeconomic status, and ethnicity. The goal is to recruit a sample size of approximately 500 participants for the quantitative survey and 30 participants for qualitative interviews.

3.3 Data Collection

3.3.1 Quantitative data

A structured questionnaire will be developed to assess participants' subjective well-being, perceptions of air quality, noise levels, and experiences with urban heat. The survey will include Demographic information, which is age, gender, income, education, and employment status. The subjective well-being scale measures utilizing established scales such as the Satisfaction with Life Scale and the Positive and Negative Affect Schedule. The survey also includes environmental stressor assessment. Questions related to perceived air quality (e.g., frequency of noticing pollution, respiratory issues), noise pollution (e.g., frequency of noise disturbances, sleep disruptions), and experiences of urban heat (e.g., discomfort during hot weather, heat-related health issues) as in Figure 1.

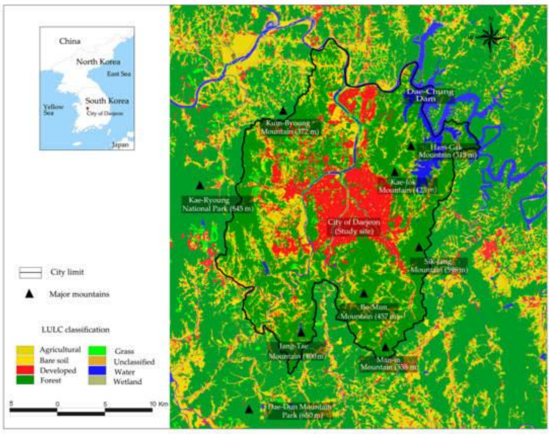

Figure 1 Spatial Distributions of Land Use/Land Cover

3.3.2 Qualitative data

In-depth interviews and focus groups will be conducted to gather rich, descriptive data about participants' experiences with environmental stressors and their impacts on well-being. The qualitative data collection will involve semi-structured interviews and focus groups.

Semi-structured interviews were conducted with 30 participants, focusing on their personal experiences with air quality, noise, and heat. Questions will explore how these factors affect their daily lives, mental health, and overall satisfaction. Focus groups were Organized with 5-6 participants per group to facilitate discussion on collective experiences and community perceptions regarding environmental stressors.

3.4 Data Analysis

3.4.1. Quantitative analysis

Statistical analyses will be performed using software such as SPSS or R. The analysis will include descriptive statistics and inferential statistics.

Descriptive statistics is to summarize demographic characteristics and subjective well-being scores. Inferential statistics analyses will be conducted to examine the relationships between environmental stressors and subjective well-being, controlling for demographic variables. Correlation analyses will also be performed to assess the strength and direction of relationships between specific environmental factors and well-being indicators.

3.4.2. Qualitative analysis

The qualitative data will be analyzed using thematic analysis. The steps will include transcription, coding, and theme development.

Transcription is audio recordings of interviews and focus groups that will be transcribed verbatim. Initial coding will be performed to identify key themes and patterns related to environmental stressors and subjective well-being. Themes will be refined and organized into categories that reflect participants' experiences and perceptions.

Ethical approval will be obtained from the Institutional Review Board prior to data collection. Informed consent will be obtained from all participants, ensuring their understanding of the study's purpose, and procedures, and their right to withdraw at any time. Confidentiality will be maintained by anonymizing data and securely storing all research materials.

4 CASE STUDY

4.1 Introduction to the Case Study Area

This study focuses on the city of Los Angeles, California, a sprawling metropolis renowned for its diverse population, significant urbanization, and complex environmental challenges. Los Angeles is characterized by a rich cultural tapestry, with residents hailing from various backgrounds, contributing to the city's vibrant social fabric. However, this diversity is juxtaposed with substantial environmental issues that have emerged as a result of rapid urban growth and industrial activity. Among these challenges, air pollution stands out as a critical concern, with Los Angeles consistently ranked among the cities with the worst air quality in the United States. Figure 2 shows that this poor air quality is primarily attributed to a combination of vehicular emissions, industrial activities, and geographical factors, such as the surrounding mountains that trap pollutants and contribute to smog formation.

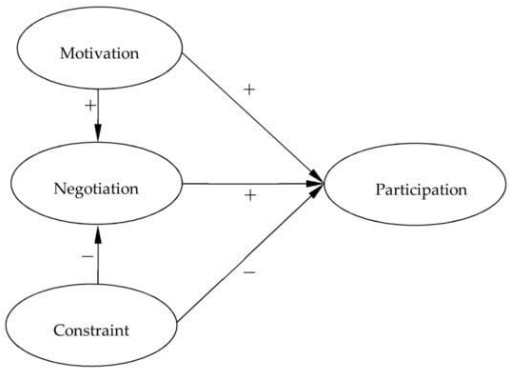

Figure 2 A Conceptual Diagram of the Constraint-Effect-Mitigation (CEM) Model

In addition to air pollution, the city experiences high levels of noise pollution, resulting from a multitude of sources including heavy traffic, ongoing construction projects, and the vibrant entertainment scene that characterizes the area. The constant hum of urban life can be overwhelming, particularly in densely populated neighborhoods where noise levels can reach disruptive levels. Furthermore, the urban heat island effect is pronounced in Los Angeles, where surface temperatures are significantly higher than those in surrounding rural areas. This phenomenon is particularly evident during the summer months, when heat waves can lead to dangerously high temperatures, exacerbating discomfort and posing health risks to residents. Understanding these environmental stressors is essential for assessing their impacts on the subjective well-being of Los Angeles residents and developing effective interventions.

4.2 Data Collection in Los Angeles

To gain a comprehensive understanding of the relationship between environmental stressors and subjective well-being in Los Angeles, a survey was conducted among 500 residents across various neighborhoods. The selected neighborhoods included densely populated areas such as downtown Los Angeles and West Los Angeles, as well as neighborhoods with more green space, such as Griffith Park. This diverse selection allowed for a broad representation of the city's demographic and socioeconomic landscape. The survey aimed to assess residents' perceptions of air quality, noise levels, and experiences with heat, alongside their self-reported well-being. Questions were designed to capture not only objective measures of environmental stressors but also subjective assessments of how these factors influenced daily life and overall happiness.

In addition to the survey, in-depth interviews were conducted with 30 residents who were selected from the survey participants. These interviews aimed to provide richer qualitative insights into individual experiences and perceptions related to environmental stressors. Participants were chosen to represent a range of demographics, including age, gender, and socioeconomic status, ensuring a comprehensive understanding of the varied impacts of environmental stressors across different community segments. To further facilitate community engagement and discussion, focus groups were organized in various community centers throughout the city. These focus groups allowed residents to share collective experiences, fostering a sense of community while also highlighting common challenges related to air quality, noise, and urban heat. The combination of quantitative and qualitative data collection methods provided a holistic view of the impacts of environmental stressors on subjective well-being in Los Angeles.

4.3 Key Findings

The quantitative analysis revealed significant correlations between poor air quality and lower subjective well-being scores among participants. Those living in areas with higher levels of air pollution reported not only increased rates of anxiety but also lower overall life satisfaction. This finding aligns with existing literature that highlights the psychological impacts of environmental degradation. Participants expressed that the visible smog and persistent air quality alerts contributed to a pervasive sense of unease, affecting their daily activities and mental health.

Noise pollution also emerged as a significant factor negatively impacting well-being. Residents living near busy roadways reported experiencing sleep disturbances and heightened stress levels, which were corroborated by their self-reported well-being scores. Many participants described noise as a constant source of irritation that disrupted their daily routines, leading to frustration and decreased productivity. The qualitative data further illuminated these experiences, with participants sharing anecdotes about the challenges of trying to concentrate or relax in environments filled with constant noise.

Urban heat was identified as another critical stressor associated with feelings of discomfort and frustration, particularly among vulnerable populations such as the elderly and those with pre-existing health conditions. The analysis indicated that individuals in these groups were more likely to report negative health outcomes during heat waves, including increased irritability and fatigue. The qualitative data provided deeper insights into how urban heat exacerbated feelings of stress and social withdrawal. Participants in Table 1 discussed how extreme temperatures discouraged outdoor activities and led to decreased engagement in community events, further isolating them from social networks.

Variables	Past Two Weeks		Usual Use	
	Group	Percent of Respondent (%)	Group	Percent of Respondent (%)
Number of visits	Almost everyday	1.5	Almost everyday	2.3
	5–6 times/week	0.3	4–6 times/week	2.3
	3–4 times/week	7.2	1–3 times/week	23.0
	1–2 times/week	23.8	1–3 times/month	30.8
	1 time/2 weeks	19.8	1–3 times/year	27.5
	No visit	47.5	1 time/years	4.5
			No visit	9.8
	Total	100.0%	Total	100.0
Amount of time spent *	Less than 1 h	28.6	Less than 1 h	25.2
	1–2 h	47.1	1–2 h	44.9
	2–3 h	18.6	2–3 h	23.3
	3–4 h	4.3	3–4 h	5.5
	4–5 h	1.0	4–5 h	0.6%
	More than 5 h	0.5	More than 5 h	0.6
	Total *	100.0%	Total *	100.0

Table 1 Frequency of Visits and Amount of Time Spent in the UGS within the Past Two Weeks and Usual Use

Overall, the findings from this case study underscore the interconnected of environmental stressors and subjective well-being in Los Angeles. By illuminating the specific ways in which air quality, noise pollution, and urban heat impact residents' lives, this case study highlights the urgent need for targeted public health interventions and urban planning strategies that prioritize environmental quality and community health. Addressing these issues is essential for improving the overall well-being of urban residents and fostering more resilient communities in the face of ongoing environmental challenges.

5 DISCUSSION

5.1 Interpretation of Findings

The findings of this study underscore the profound impact of environmental stressors on subjective well-being. The quantitative data align with existing literature, confirming that poor air quality, noise pollution, and urban heat are significant predictors of decreased life satisfaction and increased psychological distress. This correlation is not merely coincidental; it reflects a complex interplay between environmental conditions and human health outcomes. The quantitative analysis revealed that individuals exposed to higher levels of pollution and noise reported lower scores on well-being scales, indicating a clear relationship between environmental quality and mental health.

Variables	Positive Affect/Negative Affect [1]			Life Satisfaction [2]		
	Group	Classification Criteria	Percent of Respondents (%)	Group	Classification Criteria	Percent of Respondents (%)
Number of visits	Heavy user group	1 or more times/week	32.8	Heavy user group	1 or more times/week	27.5
	Moderate user group	1 time/2 weeks	19.8	Moderate user group	1–3 times/month	30.8
	Non-user group	No visit	47.5	Light & Non-user group	1–3 times/year, and no visit	41.8
	Total		100	Total		100
Amount of time spent	Long stay group	more than 2 h/visit	24.3	Long stay group	2 h or more/visit	29.9
	Medium stay group	1–2 h/visit	47.1	Medium stay group	1–2 h/visit	44.9
	Short stay group	less than 1 h/visit	28.6	Short stay group	less than 1 h/visit	25.2
	Total [3]		100	Total [3]		100

Table 2 Segmented Respondent Groups by Frequency of Visit and Amount of Time Spent in UGS

Moreover, the qualitative insights from Table 2 enrich this understanding, revealing the emotional and social dimensions of living in environments characterized by these stressors. Participants articulated feelings of anxiety and frustration that stemmed from their daily experiences with pollution and noise. Many described a sense of helplessness, particularly in relation to air quality, which they felt was beyond their control. This emotional burden is crucial to recognize, as it emphasizes that environmental stressors do not merely impact physical health; they also affect mental and emotional well-being. The qualitative narratives illustrate the lived experiences of individuals, providing a context that quantitative data alone cannot capture. They highlight the need for a more nuanced understanding of how environmental conditions shape not just health outcomes, but also the overall quality of life.

Furthermore, the findings suggest that the effects of these stressors are cumulative, meaning that individuals exposed to multiple environmental challenges are likely to experience compounded negative impacts on their well-being. This cumulative effect necessitates an integrated approach to public health and urban planning, where solutions address multiple stressors simultaneously rather than in isolation.

5.2 Air Quality and Subjective Well-Being

The negative impact of air pollution on mental health is particularly concerning and warrants significant attention from policymakers and public health officials. The findings suggest that individuals living in areas with poor air quality experience not only physical health issues, such as respiratory diseases and cardiovascular problems, but also significant psychological burdens. This aligns with previous research indicating that air pollution can lead to increased rates of anxiety and depression. The physiological mechanisms underlying these effects are complex; for instance, exposure to fine particulate matter (PM2.5) has been linked to inflammation and oxidative stress, which can adversely affect brain function and mood regulation.

The feelings of helplessness expressed by participants highlight the need for effective public health interventions and policies aimed at improving air quality. Many respondents indicated that they felt powerless to change their circumstances, which can lead to learned helplessness—a psychological condition that exacerbates feelings of anxiety and depression. This underscores the importance of community-level interventions that empower residents to take action. For instance, promoting cleaner transportation options, such as public transit, cycling, and walking, can not only improve air quality but also foster a sense of agency among residents. Implementing stricter emissions regulations for industries and vehicles is also critical; such policies can lead to significant improvements in air quality over time.

Moreover, public awareness campaigns that educate residents about the health impacts of air pollution can encourage community engagement and advocacy for cleaner air initiatives. By providing residents with the knowledge and tools to advocate for their health, communities can mobilize to push for policy changes that prioritize air quality improvements.

5.3 Noise Pollution and Mental Health

The impact of noise pollution on subjective well-being is evident in both quantitative and qualitative data. Chronic exposure to noise has been linked to increased stress levels, sleep disturbances, and cognitive impairments, which can further diminish quality of life. The findings emphasize the importance of urban planning that considers noise reduction strategies. For instance, the creation of sound barriers along busy roadways can significantly reduce noise exposure for nearby residents. Zoning regulations that separate residential areas from noisy commercial and industrial zones can also be effective in minimizing noise pollution.

Additionally, promoting quieter transportation alternatives, such as electric vehicles and improved public transit systems, can contribute to reducing overall noise levels in urban areas. The qualitative data revealed that many participants expressed a desire for quieter neighborhoods, indicating a strong community preference for noise reduction. This presents an opportunity for urban planners to engage with residents in the design of noise mitigation strategies, ensuring that solutions are tailored to the specific needs and preferences of the community.

The implications of noise pollution extend beyond individual well-being; they also impact social dynamics within communities. High levels of noise can lead to increased irritability and conflict among neighbors, undermining social cohesion. Therefore, addressing noise pollution is not only a public health issue but also a matter of fostering healthy, connected communities.

5.4 Urban Heat and Community Engagement

The relationship between urban heat and subjective well-being is particularly relevant in the context of climate change. The findings suggest that rising temperatures not only pose direct health risks, such as heat exhaustion and heat stroke, but also contribute to social isolation and decreased community engagement. Vulnerable populations, such as the elderly and low-income residents, may be disproportionately affected by urban heat, exacerbating existing inequalities. These groups often lack access to air conditioning or safe, cool spaces, making them more susceptible to the adverse effects of extreme heat.

Strategies to mitigate urban heat, such as increasing green spaces and implementing cool roofs, can enhance residents' comfort and promote social interaction. Green spaces not only provide shade and cooling but also serve as communal

areas where residents can gather and connect, fostering a sense of community. The qualitative data revealed that participants who lived near parks or green areas reported higher levels of life satisfaction, indicating that access to nature plays a crucial role in well-being.
Community engagement is essential in developing effective strategies to combat urban heat. Involving residents in the planning and implementation of green infrastructure projects can ensure that these initiatives meet the specific needs of the community. Educational programs that inform residents about the risks of urban heat and encourage them to take proactive measures, such as using fans, staying hydrated, and seeking shade, can also empower individuals to manage their well-being during extreme heat events.
The results of this study have significant implications for urban planning and public health policies. Policymakers should prioritize initiatives aimed at improving air quality, reducing noise pollution, and mitigating urban heat to enhance the well-being of urban residents. Community engagement in the development of these initiatives is essential to ensure that the voices of affected populations are heard. Additionally, educational programs that raise awareness about the health impacts of environmental stressors can empower residents to advocate for healthier living conditions.
In summary, the discussion of these findings highlights the inter connected of environmental stressors and subjective well-being. By recognizing the complex relationships between air quality, noise pollution, urban heat, and mental health, stakeholders can develop more effective, holistic strategies that not only address individual stressors but also enhance overall quality of life in urban environments.

6 CONCLUSION

This study provides compelling evidence of the impact of environmental stressors─air quality, noise, and urban heat─on residents' subjective well-being. The findings highlight the urgent need for comprehensive strategies to address these challenges in urban environments. As cities continue to grow and face increasing environmental pressures, understanding the relationship between these stressors and well-being becomes paramount for promoting public health and enhancing quality of life.
The evidence gathered in this research underscores the multifaceted nature of subjective well-being, which is intricately linked to the quality of the environment in which individuals live. Poor air quality, characterized by high levels of pollutants such as particulate matter and nitrogen dioxide, has been shown to correlate with not only physical health issues but also significant psychological burdens. Participants in the study reported feelings of anxiety and frustration related to air pollution, indicating a direct impact on their mental health. Similarly, chronic exposure to noise pollution has been linked to increased stress levels, sleep disturbances, and cognitive impairments, all of which adversely affect overall life satisfaction. The urban heat phenomenon, exacerbated by climate change and urbanization, further complicates the landscape of well-being, particularly for vulnerable populations who may lack adequate resources to cope with extreme heat conditions.
Given these findings, it is clear that a holistic approach is necessary to mitigate the adverse effects of environmental stressors on urban residents. Comprehensive urban planning must prioritize sustainable practices that enhance air quality, reduce noise pollution, and implement effective heat mitigation strategies. This could involve investing in green infrastructure, such as parks and tree canopies, which not only improve air quality but also provide cooling effects and promote social interaction among community members. Noise reduction strategies, including better urban design and zoning regulations, can help create quieter, more peaceful living environments. Additionally, policies aimed at reducing greenhouse gas emissions and promoting renewable energy sources can significantly contribute to improving air quality and mitigating urban heat.
Future research should continue to explore the complex interactions between environmental factors and subjective well-being, considering additional variables such as socioeconomic status, access to green spaces, and community resources. Understanding how these factors intersect can provide deeper insights into the challenges faced by different demographic groups. For instance, low-income communities often bear a disproportionate burden of environmental stressors, exacerbating existing inequalities in health and well-being. Longitudinal studies could provide valuable insights into the long-term effects of environmental stressors on mental health and well-being, allowing researchers to track changes over time and assess the effectiveness of interventions.
Moreover, community engagement is crucial in addressing environmental stressors and enhancing subjective well-being. Involving residents in the planning and decision-making processes can ensure that their needs and preferences are considered, leading to more effective and sustainable solutions. Community-led initiatives, such as neighborhood clean-up projects or local advocacy for better urban policies, can empower residents and foster a sense of ownership over their environment. Such engagement not only enhances social cohesion but also promotes mental well-being by creating supportive networks and fostering a sense of belonging.
In conclusion, addressing environmental stressors is not only a matter of public health but also a critical step towards creating sustainable, resilient urban communities. By prioritizing the well-being of residents, cities can foster environments that promote physical and mental health, enhance social cohesion, and ultimately improve the quality of life for all urban dwellers. The integration of environmental considerations into urban planning and public health policies is essential for building cities that are not only livable but also thriving. As urbanization continues to accelerate globally, the lessons learned from this study can serve as a foundation for future initiatives aimed at promoting healthier, more equitable urban environments. By recognizing and addressing the profound impacts of environmental stressors on

subjective well-being, we can work towards a future where all individuals can enjoy a high quality of life, regardless of their urban context.

COMPETING INTERESTS

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

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