Journal of Architectural Research and Development

Editors-in-Chief

Paolo Beccarelli

The University of Nottingham, UK

Rocio Maira Vidal

Spanish National Research Council, Spain

BIO-BYWORD SCIENTIFIC PUBLISHING PTY LTD
(619 649 400)
Level 10
50 Clarence Street
SYDNEY NSW 2000
Copyright © 2023. Bio-Byword Scientific Publishing Pty Ltd.
Complimentary Copy

ISSN (ONLINE): 2208-3537
ISSN (PRINT): 2208-3529

Journal of Architectural Research and Development

Focus and Scope

Journal of Architectural Research and Development is an international peer-reviewed and open access journal which is devoted to establishing a bridge between theory and practice in the fields of architectural and design research, urban planning and built environment research.

Topics covered but not limited to:

- Architectural design
- Architectural technology, including new technologies and energy saving technologies
- Architectural practice
- Urban planning
- Impacts of architecture on environment

About Publisher

Bio-Byword Scientific Publishing is a fast-growing, peer-reviewed and open access journal publisher, which is located in Sydney, Australia. As a dependable and credible corporation, it promotes and serves a broad range of subject areas for the benefit of humanity. By informing and educating a global community of scholars, practitioners, researchers and students, it endeavors to be the world's leading independent academic and professional publisher. To realize it, it keeps creative and innovative to meet the range of the authors' needs and publish the best of their work.

By cooperating with University of Sydney, University of New South Wales and other world-famous universities, Bio-Byword Scientific Publishing has established a huge publishing system based on hundreds of academic programs, and with a variety of journals in the subjects of medicine, construction, education and electronics.

Publisher Headquarter

BIO-BYWORD SCIENTIFIC PUBLISHING PTY LTD
Level 10
50 Clarence Street
Sydney NSW 2000
Website: www.bbwpublisher.com
Email: info@bbwpublisher.com

Table of Contents

Call for papers – Journal of Architectural Research and Development

ISSN (Online): 2208-3537
ISSN (Print): 2208-3529

Submission open for September - 2023

Dear Researchers,

Journal of Architectural Research and Development is an international peer-reviewed and high quality open access journal which is devoted to establish a bridge between theory and practice in the fields of architectural and design research, urban planning and built environment research.

The Journal Publishes in both online and print version. *Journal of Architectural Research and Development* publishes research and review paper in the field of:

- Architectural design
- Architectural technology, including new technologies and energy saving technologies
- Architectural practice
- Urban planning
- Impacts of architecture on environment

The *Journal of Architectural Research and Development* is published by Bio-Byword Scientific Publishing Company, it is a fast growing peer-reviewed and open access journal publisher, which is located in Sydney, Australia. As a dependable and credible corporation, it promotes and serves a broad range of subject areas such as medicine, construction, education and electronics for the benefit of humanity. By informing and educating a global community of scholars, practitioners, researchers and students, it endeavour's to be the world's leading independent academic and professional publisher.

All Bio-Byword journals are free from all access barriers, allowing for the widest possible global dissemination of their manuscripts and highest possible citations. Bio-Byword publisher online submission will go through a rapid peer review and production, making the process of publishing simpler and more efficient, which benefit from its user friendly online submission system that reduces the overall time from submission to publication.

Acceptance Notification: Within 21 days from the date of manuscript submission

Send your manuscript to the editor at: **info@bbwpublisher.com**

Kind regards,
Editorial Office
Journal of Architectural Research and Development

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Strategies for Ramp Route Design of Highway Interchange

Xiaomin Wu*

China Merchants Chongqing Communications Technology Research & Design Institute Co., LTD., Chongqing 400067, China

***Corresponding author:** Xiaomin Wu, wuxiaomin@cmhk.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The rapid advancement of urban transportation in modern China has driven urban economic developments. However, the progressively congested traffic conditions have affected the productivity and daily life of the people. To mitigate the congestion problem, necessary road designs should be implemented along the highways, for example highway interchanges. The application of highway interchanges in past cases have proven to effectively avoid traffic flow conflicts, reduce highway traffic congestion, and reduce traffic accidents, this is conducive to ensuring the safety and efficiency of the highway. In order to improve the safety and convenience of urban road traffic, this paper analyzes the strategy of using interchange ramp route designs for highway traffic.

Keywords: Interchange ramp; Route design; Variable speed lane

Online publication: July 28, 2023

1. Introduction

Due to increased congestion at the intersection of high-grade roads and arterial roads, the use of interchanges as the entrance and exit of urban expressways has received more attention due to its potential to improve China's urban highway transportation. Effective solutions will increase the driving speed and reduce the incidence of traffic accidents, thus when carrying out interchange design work, it is important to improve the level of ramp design [1]. A ramp is a connecting lane specially set up for the turning traffic flow of two intersecting main lines, it acts as the acceleration and deceleration transition section for vehicle speed changes. The selection and design of the ramp can affect the overall use of the road, different forms of ramps can be combined to form different interchange shapes to meet the needs of highway interworking developments.

2. Design of the ramp

2.1. The form of the ramp

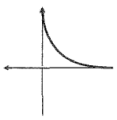
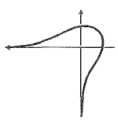
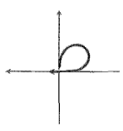
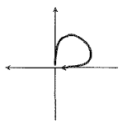
The current form of highway interchange ramps includes two aspects: the left–turn ramp to meet the left turn traffic demand, and the right–turn ramp to meet the right turn traffic demand. Due to China's right-hand traffic practice, generally when exiting the arterial road the using a right-turn ramp, a 90° right turn will allow the driver to directly enter the right side of the intersecting road. The entire driving process is more convenient and causes less interference to traffic in other directions within the intersection range. Vehicles making a left turn generally need to turn 90–270° before entering another road, during this process, there are intersections, conflicts with the traffic flow (going straight or turning right), and sometimes a flyover bridge may be needed. Currently, the forms of left-turn ramps that are commonly used include

direct, semi-direct and indirect interchanges, the scale and form of an interchange are usually restricted and closely related to the left-turn ramp. The shape and position of the left-turn ramp can be flexibly changed according to the actual situation, as different forms can be used to gradually form different interchanges. All interchanges are formed by combining/deforming the above three forms. Generally, the application of direct interchanges is suitable for when there is a large number of left-turning vehicles, whereas semi-direct interchanges should be set according to the actual left-turning traffic volume and terrain characteristics. If the transfer volume is relatively small, the indirect type can be used and the turning part can be set as an arc, drop shape or ellipse [2].

2.2. The speed of the ramp

The ramp functions as the entrance and exit of vehicles into the main traffic line, thus the traffic volume must be smaller than the main line, and is limited by various factors such as terrain, scale, land use, function, etc. The driving speed of the ramp part should also be slower than the main line, however it cannot be too slow. That is because China's "Urban Road Code" and "Highway Route Design Code" have clearly stipulated that the speed of the ramp should not be lower than 60% of the main line speed, and in special cases not lower than 50%. This standard is set to avoid a large speed gradient between the ramp and the main line to prevent congestion and traffic accidents. The speed of the ramp part should also be consistent with the actual traffic flow and traffic flow direction. For ramps with large traffic volume, the speed should be appropriately increased to increase the capacity of the ramp part [3]. The regulations on the design speed of the ramp are clearly stipulated in the "Detailed Rules for the Design of Highway Intersections" (JTG/T D210214), as shown in **Table 1** [4].

Table 1. Design speed range of the basic section of the ramp

Ramp type		Direct connection		Semi-inline		Circular ramp	
		Standard type	Variant	Inside turn	Outside turn	Standard type	Variant
General interchange	Design speed (km/h)	40–60	30–40	/	40–60	30–40	30–40
	Ramp form			/			
Hub interchange	Design speed (km/h)	60–80	50–60	60–80	40–60	40	40
	Ramp form						

3. Linear design of the ramp

3.1. Design of variable speed lanes

There are two types of speed-changing lanes: direct and parallel. In most cases, the acceleration lane uses the parallel type, whereas the deceleration lane has to use the direct type. The overall length of the deceleration lane can have a direct impact on the effect of vehicle deceleration. According to the actual driving speed of the vehicle, the deceleration process can be divided into three different stages: In the first stage, after the driver recognizes the direction and enters the gradual road section, the vehicle is still driving at a constant speed at the initial speed of the diversion point; in the second stage, the vehicle enters the deceleration lane and is affected by inertia. The driver needs to gradually decelerate with the help of driving resistance while releasing the accelerator. Usually, the initial deceleration time is about 3s, and the deceleration rate is relatively small; in the third stage, the vehicle enters the deceleration lane, and the drivers behind can already fully understand the ramp speed limit requirements, and gradually implement any necessary deceleration to the ramp design speed.

There is also a certain difference in the speed of vehicles in the diversion area. Based on the secondary deceleration theory, the deceleration process of ramp vehicles can be analyzed and divided into three stages: During the first stage, the vehicle enters the triangular gradient and then the deceleration lane at the initial speed of the diversion point; at the second stage, the initial deceleration starts with the help of driving resistance and the car engine; as for the third stage the final deceleration operation is performed with the help of the car brake [5].

3.2. Longitudinal section design

When designing the longitudinal section of the ramp, it is necessary to comprehensively consider various factors such as geology, topography, clearance, economy, and safety to ensure that the design is rational. Linear combination can be used to optimize the relationship between the main line of the ramp, the longitudinal slope, and the road to be crossed. This ensures the balance and coordination between various indicators of the plane alignment and longitudinal section alignment, which leads to a smooth and continuous three–dimensional alignment of the longitudinal section of the ramp.

However, because the actual range of ramp longitudinal section design is not consistent with the plane line length, it is not possible to fully refer to the plane line design measures. Normally, the starting point of the longitudinal slope of the ramp is at the end of the vehicle diversion point, and the ending point is at the end of the vehicle merging point. The longitudinal slope and transverse slope of the variable speed lane before the ending point changes with the transverse slope and longitudinal slope of the main line. When determining the starting point and ending point of the longitudinal slope and transverse slope of the ramp, the actual situation of the transverse slope and longitudinal slope of the main line must be fully considered, and the synthetic slope method or the average gradient method should be used to calculate the transverse slope and longitudinal slope.

When designing the slope of a single ramp, care should be taken to ensure that the minimum slope length of the ramp is compliant with construction requirements. As for the vertical curve of the ramp, the minimum length and the minimum slope should also be within construction requirements. Towards the end of the ramp, the radius of the vertical curve should be increased to ensure that the driver can have sufficient front view distance, which provides additional safety.

3.3. Cross-sectional design

Highway ramps consist of four parts: the lane, the hard shoulder, the curb strip, and the soil shoulder. In general, the width of the cross-sectional diagram of the ramp should be based on the traffic volume. When the traffic volume is not large, a single lane with a width of 9 m is used. According to the length of the

ramp, it can be widened for overtaking. If the traffic volume is large, a one-way two-lane ramp is required, and the general roadbed width is 10.75 m or 12.5 m. Some directions that require two-way driving can adopt the mode of opposite double lanes, however the two-way lanes should be separated, and the width of the roadbed is generally 15 m. If the lane is a mixed vehicle lane, the width of the non-motor vehicle part should be calculated according to the actual traffic volume [6].

3.4. Design of ramp connection

The ramp connection is the connection area between the two ends of the ramp and the main line. This part includes the auxiliary lane, the upper lane of the variable speed vehicle, and the entrance and exit of the ramp. Previously, if you were behind a straddle structure, you had to keep at least 150 m away from the structure. Concurrently, to improve vehicle deceleration efficiency, the exit position should be set in the uphill area, while downhill entrance positions can improve the acceleration efficiency of the vehicle. In addition, before the ramp merges into the main line, the triangular area where the main line (100 m) and the ramp (60 m) are located should be visually clear, and a variable speed lane should be set at this position [7].

3.5. Ramp superelevation design

In order to keep the project scale of the interchanges within a reasonable range, the horizontal curve index within the design range is usually low. Because superelevation will affect the safety of driving, full emphasis must be given when selecting the superelevation value and determining the superelevation transition mode [7]. In case of normal superelevation transition, a superelevation transition section should be set for the middle part of the straight line on the ramp. The superelevation circular curve and the length of the transition section is determined by the maximum superelevation value, the superelevation gradient rate, the position of the rotation axis, and the design of the ramp.

As a whole, the focus of the superelevation transition section design work mainly includes three aspects: (1) If the superelevation transition section contains a transitional curve, the superelevation transition section as a whole should be in the transitional curve. If there is no need to set a transitional curve, within the range of the superelevation transition section, one–third to one–half of the length should be in a circular curve, and the rest can be a straight line. If there is a connection between two circular curves, a transitional curve should be set in between and combined with the setting of the superelevation transition section as much as possible; (2) When the superelevation gradient is selected, the part of the regular road section on the ramp and the part with basically no change in width shall be adjusted according to the relevant requirements. However, if the location of the toll booth or the width of the ramp itself changes significantly when selecting the gradient rate, the influence of the width change must be taken into account, especially if there is a high gradient in the ramp. In order to improve drainage [8], an ultra-high gradient rate should be selected. (3) Superelevation transition methods mainly include straight line method and cubic parabola method, the straight line method is less complex but more rigid, and will cause the edge of the road to appear too distorted. Thus, the method is mainly used for the beauty, safety and smoothness of driving. In most cases, the method of cubic parabolic transition is used instead [9].

3.6. Ramp lighting design

According to relevant research, if the night lighting effect of the highway ramp is good, the road use efficiency can be increased by one-fourth to one-third, which can also generate higher economic benefits. From a practical point of view, not only can optimizing lighting design improve the safety of road driving at night, it can also increase the overall infrastructure standards of the city. Lighting design should be considered for the part of the interchange ramp where there is a need for lighting. The most commonly used

lamps include sodium lamps, high-pressure mercury lamps, etc. The height of the lamps should be set according to the road width and layout method, usually 6–8 m is appropriate. The installed height of lamps has great impact on the distance between lamps. In general, the distance between adjacent luminaires should be set at 25–30 m, the cantilever length of luminaires should be 2–4 m, the elevation angle should be within 15°, and the illuminance and uniformity of the lamps should also be reasonably controlled [10].

3.7. Landscape design

According to the "Highway Route Design Code", when designing the ramp route, attention should be paid to the landscape of the relevant location. The location landscape can be incorporated with the linear layout of the ramp, which provides beautification while still protecting the environment. Because the overall shape of the interchange is mainly a spatial form, it is necessary to adopt the combination of flat and vertical planes for landscape design. While doing so, care should be taken to avoid disrupting the natural ecological landscape to improve the overall aesthetic level of the landscape [11].

4. Conclusion

As a summary, the highway interchange ramp is an important component in the process of road traffic development because it has a profound impact on the convenience, effectiveness, and safety of traffic. Highway interchanges are important areas for traffic to turn, gather and evacuate, it is also one of the main factors affecting the smoothness of traffic. Therefore, during the ramp design process, it is necessary to ensure that the plane, longitudinal section, cross section, ramp, connecting parts, ancillary works, and overall shape are all in reasonable condition. This will effectively improve the application of the ramp part, while also ensuring the convenience and safety of road traffic.

Disclosure statement

The author declares no conflict of interest.

References

[1] Qin T, 2020, Analysis of Key Influencing Factors and Precautions for Sight Distance Design of Expressway Interchanges. Urban Construction, 2020(2): 206.

[2] Liu L, Yang Y, 2020, A New Method for the Design of Horn-shaped Intercommunicating Horn Heads Based on JSL-route Expert System. Sino-foreign Highway, 40(2): 306–309.

[3] Lin J, 2020, Research on the Minimum Length of the Weaving Area of the Freeway Interchange Ramp Section, dissertation, Chongqing Jiaotong University.

[4] Ministry of Transport of the People's Republic of China, 2017, Guidelines for Design of Highway Grade-separated Intersections, JTG/T D21-2014.

[5] Li Q, 2020, Research on the Diversion Area Setting of the Three-lane Ramp Exit of the Expressway Interchange, dissertation, Chang'an University.

[6] Jiang H, 2020, Research on Wind Blowing Snow Control Technology of Beijing-Xinjiang Expressway (G7) at the Northern Foot of East Tianshan Mountain in Xinjiang, dissertation, Beijing Jiaotong University, 2020.

[7] Zhong W, Cao J, Zhang J, et al., 2021, Research on the Minimum Distance Between Adjacent Entrances on the Same Side of the Main Line of Interchanges. Highway Traffic Science and Technology, 38(9): 148–158.

[8] Chen C, 2021, Discussion on Line-of-sight Distance of Expressway Interchange. Encyclopedia Forum Electronic Magazine, 2021(9): 1708–1709.

[9] Li X, 2022, Safety Design and Evaluation of the Exit Ramp of Expressway Interchange. Traffic World (Last Period), 2022(8): 32–34,54.

[10] Yang Y, 2022, Schematic Design of Ramp Bridge A of Fuling Jiangdong Binjiang Road West Bridge Overpass. Enterprise Technology and Development, 2022(6): 130–132.

[11] Liang Z, 2022, Design Analysis of Expressway Interchange. North Communications, 2022(9): 4–6.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Building Daylight Simulation Analysis Based on Ladybug + Honeybee Parametric Approach: A Case Study of Gando Primary School

Weizheng Tong*

Department of Architecture and Art, The North China University of Technology, Beijing 100041, China

***Corresponding author:** Weizheng Tong, tunggiya_wz@163.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The Gando Primary School project faces several challenges like extreme environmental constraints, resource scarcity, and design requirements. These challenges include the hot climate of Burkina Faso, economic underdevelopment, building material scarcity, and lack of electrical resources. To implement an architectural design for the classrooms that accommodates these difficulties, especially in the absence of an electrical system, architect Francis Kéré employed various passive design strategies that can provide shelter from the rain and heat while achieving essential lighting levels and ventilation. This paper used Gando Primary School as the research object and utilized the parametric tools of Ladybug + Honeybee (L + H) to conduct numerical simulations and evaluations of the building's daylighting, glare analysis, and indoor thermal comfort. The aim of this study is to investigate the application of passive design strategies in energy conservation under extreme environmental conditions, propose a parametric energy-saving evaluation strategy with L + H, and explore energy-saving design ideas in economically underdeveloped Third World countries.

Keywords: Gando Primary School; Parametric; Passive energy conservation; Ladybug + Honeybee

Online publication: July 28, 2023

1. L + H parametric research methods and theoretical foundations

African architect Diébédo Francis Kéré, winner of the 44th Pritzker Prize in 2022, is renowned for his impactful work in Burkina Faso, a landlocked country in West Africa that has harsh climate and limited resources [1]. The Gando Primary School project in Burkina Faso showcases Kéré's ability to consider local climate and construction constraints [2]. This paper examines the daylighting and energy-saving effects of the Gando Primary School using the parametric tools Ladybug + Honeybee (L + H), in order to establish a comprehensive architectural energy-saving optimization mechanism.

1.1. Introduction to L + H tools

Ladybug and Honeybee (L + H) tools form a comprehensive architectural system, with separate computational cores and additional toolsets. Ladybug supports meteorological data processing, offering an interactive interface through Grasshopper for bioclimatic charts and passive design strategies. It provides solar path, wind speed, and other data visualizations. Honeybee integrates EnergyPlus, Radiance, Daysim, and Butterfly for building energy consumption, light environment, and ventilation simulations respectively [2]. L + H tools support performance analysis throughout the design cycle, as shown in **Table 1**.

Table 1. L + H Parametric tool function summary

Tool	Function	Performance analysis	Computing core
Ladybug	Environmental analysis Climate meteorological analysis data visualization	Climate Data Map Sun path Wind speed and direction Shadow simulation Enthalpy chart Adaptive Comfort Chart etc.	Python
Honeybee	Energy consumption simulation Sunshine simulation Adaptive computing	Calculation of thermal comfort Annual Solar Analysis Glare analysis Visualize energy balance etc.	EnergyPlus Radiance Daysim OpenStudio Python

2. Gando primary school parametric building daylighting evaluation strategy construction

2.1. Meteorological data extraction

The meteorological data EPW file used in this study came from the TMYx dataset, which is a typical meteorological file obtained from the ISD (U.S. National Oceanic and Atmospheric Administration's Integrated Surface Database) and provides hourly data for 2021 using the TMY/ISO 15927-4:2005 method. The individual annual ISD files were created using the general principles of the IWEC (International Weather for Energy Calculations) typical meteorological year published in 2001. The resulting files have been peer-reviewed by relevant parties. ERA5 data is a comprehensive, satellite-based global grid solar radiation dataset provided by Oikolab, with reliable and valid data sources. Ladybug tools can extract hourly temperature, humidity, wind speed, and solar radiation intensity data from EPW files for the region.

Gando Primary School is located in Poussoaka County, under the jurisdiction of Bourgou Province in the Central East Region of Burkina Faso. Meteorological data for this region is not available, thus meteorological data from Ouagadougou, the capital of Burkina Faso, which is geographically close and has similar climatic characteristics was used instead.

2.2. Daylight design strategy analysis

The acquired EPW meteorological data file was imported into Ladybug Tools, and quantitative analysis of the region's climatic and meteorological conditions was performed by setting relevant field parameters at the Ladybug battery port. At this stage, multi-dimensional energy-saving strategies can be formulated based on the local average annual meteorological conditions. The building's passive energy-saving design strategy can be adjusted in real-time according to changes in the climate timeline.

As shown in **Figure 1**, Ladybug Tools was used to generate the region's annual average dry bulb temperature chart. The region experienced high temperatures throughout the year, with March–June having the most concentrated high temperatures, with highest daily temperatures reaching above 42°C. As shown in **Figure 2**, Ladybug Tools was also used to generate the region's annual average relative humidity chart, the visualization showed that the region has a rainy season between June–October. In response to this

unique climate, Kéré designed a massive overhanging tin roof and thick stone foundation for Gando Primary School; the tin roof absorbs solar radiation, shields sunlight, and prevents external heat from entering; the stone foundation prevents rainwater from flooding the interior and effectively protects the clay brick walls from rainwater erosion. In this way, the impact of extreme weather can be mitigated while ensuring the safety and stability of the building.

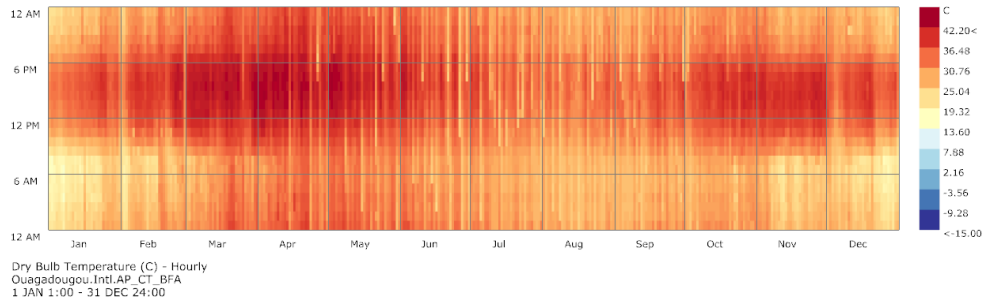


Figure 1. Annual average dry bulb temperature – hourly (drawn by the author)

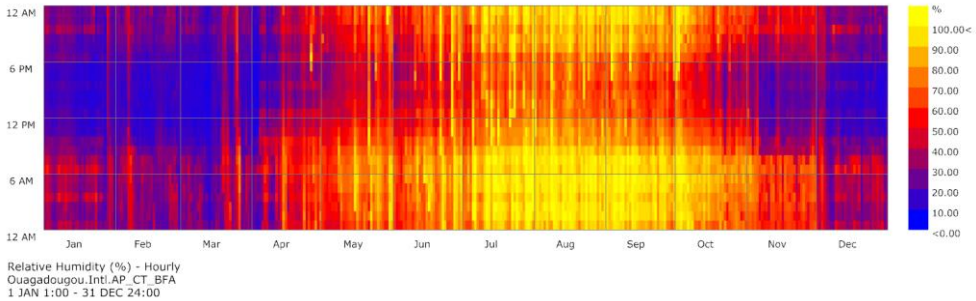


Figure 2. Annual Average Relative Humidity Chart – hourly (drawn by the author)

2.3. Building daylighting evaluation indicators based on L + H

Since there are no relevant standards for daylighting design of campus buildings in the country and region where the Gando Primary School project is located, the parameter settings and relevant standards in this simulation are based on the national standards of China, with the "Architectural Daylighting Design Standard" (GB50033-2013) as the relevant evaluation standard. The focus of this paper is to analyze and explore the effects of building daylighting under parametric simulation. Due to the constraints of the COVID–19 pandemic during the experimental period, on-site measurements could not be conducted, thus the study does not delve into the specifics of building construction and only the critical values of the lighting coefficient under the parametric model were considered.

(1) Indoor illuminance

Indoor illuminance is generally defined as the luminous flux per unit area passing through a work plane indoors, which indicates the extent to which fixed work planes, such as desks, are illuminated by light. Although it cannot directly reflect the perception of the human eye, it can objectively quantify the brightness on the work plane, thus making it a commonly used indicator for evaluating indoor light environment quality. In the "Architectural Daylighting Design Standard" (GB50033-2013), the standard value of natural light for primary school classrooms is 450lx [3].

(2) Daylight Glare Probability (DGP)

Daylight Glare Probability (DGP) is a robust glare metric standard used to evaluate the probability of glare in buildings from windows, and it is considered the most accurate glare model for human eye

perception. DGP values represent the probability of sunlight entering through windows and causing glare interference to indoor occupants, with effective values ranging from 0.2 to 0.8. Intuitively, when DGP = 0.2, it indicates that 20% of people feel glare interference in that environment. The value is calculated using equation (1):

$$DGP = 5.87 \times 10^{-5} E_v + 9.18 \times 10^{-2} \log\left(1 + \sum_i \frac{L_{s,i}^2 \omega_{s,i}}{E_v^{1.87} P_i^2}\right) + 0.16 \quad (1)$$

where E_v represents the vertical illuminance of the eye, L_s is the brightness of the glare source, ω is the solid angle of the glare source, and P_i is the Guth position index.

The passive daylighting design of Gando Primary School was quantitatively simulated and analyzed from the dimensions of indoor illuminance and daylight glare probability, with the control objective of each link being "and whether the classroom daylighting comfort requirements are met according to relevant standards based on the solar radiation received by the classroom work plane." The illuminance should meet the minimum value required for teaching activities, glare should be controlled below the acceptable threshold, and the indoor daylight factor should be maintained at an appropriate level.

3. Evaluation of energy-saving effect of Gando Primary School L + H parametric architecture

3.1. Daylight environment simulation

The indoor daylight environment of a Gando Primary School classroom unit was simulated through utilizing the Ladybug and Honeybee collaborative workflow. The .epw format weather file was input into Ladybug, which then connects with Radiance, Daysim, Energyplus, and other plugins on the Grasshopper platform using Honeybee. This bridges the gap between building performance calculation and parametric simulation [4]. The plugin processes input data through algorithms and visualizes simulated data using data charts. The Ladybug and Honeybee versions used were 1.5.0.

Due to a lack of material resources, natural lighting was the only lighting method for Gando Primary School classrooms. Therefore, the indoor illuminance level of natural light inside Gando Primary School classrooms is an essential indicator to measure the lighting comfort level. Illuminance, expressed in lux, is a physical quantity describing the light power from all directions, used to ensure the required intensity of illumination in a space. The illuminance on the desktop surface in the classroom was used as the basis for evaluating the lighting level of the teaching space. According to the "Building Daylighting Design Standard" (GB50033-2013), the standard value of indoor natural illuminance for educational buildings should be 450lx; discomfort may occur if the value is lower or higher than this standard.

A satisfactory lighting condition can be considered if the illuminance satisfaction in the core work area reaches more than 50%. The illuminance satisfaction limit is at 150-300lx.

As shown in **Figure 3**, the Generate Standard CIE Sky in Honeybee was chosen as the sky model for illuminance calculation, where CIE (Critical Illuminance of Exterior) represents the outdoor natural illuminance when indoor artificial lighting needs to be fully turned on. Under this model, parameters can be input to adjust the required illuminance simulation date and time.

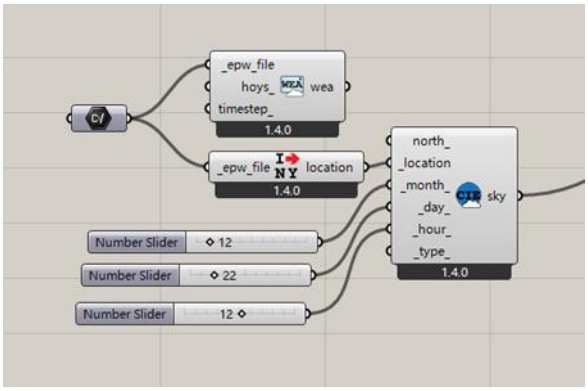


Figure 3. Sky model battery pack (drawn by the author)

3.2. Daylight environment simulation

Using the Average Sky Model (Honeybee_Generate Average sky), real sky measurement data for 8760 hours throughout the year was obtained from Gando Primary School's location, Ouagadougou. The weather data was input into the average sky model in order to calculate the monthly average illuminance by taking the average value of the same time in each month, which resulted in an objective representation of the average indoor illuminance distribution throughout the year (**Figure 4**). High illuminance values were concentrated between 12:00 and 15:00 from November to February, while more evenly distributed around 12:00 in other months. This aligns with the students' class time, achieving lighting standard of more than 450lx for most of the time, demonstrating significant natural lighting potential.

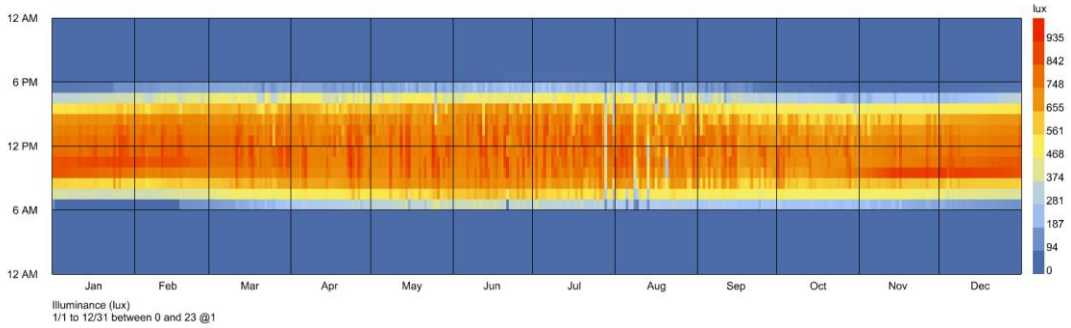


Figure 4. Annual indoor illuminance distribution (drawn by the author)

As for indoor illumination simulations, winter and summer solstices were selected as measurement dates [5], representing annual indoor illumination values. As shown in **Figure 5**, during winter solstice, natural indoor illuminance exceeding 450lx was mainly concentrated on the Southern side of the classroom, whereas the Northern side complied with control standards. During summer solstice, the area with higher illuminance shifted to the Northern side, whereas the Southern side was slightly above control standards. It is possible that due to this reason, Kéré designed adjustable louver windows for Gando Primary School classrooms, which can block excessive direct sunlight, address excessive illuminance, and dissipate excess indoor heat through convection.

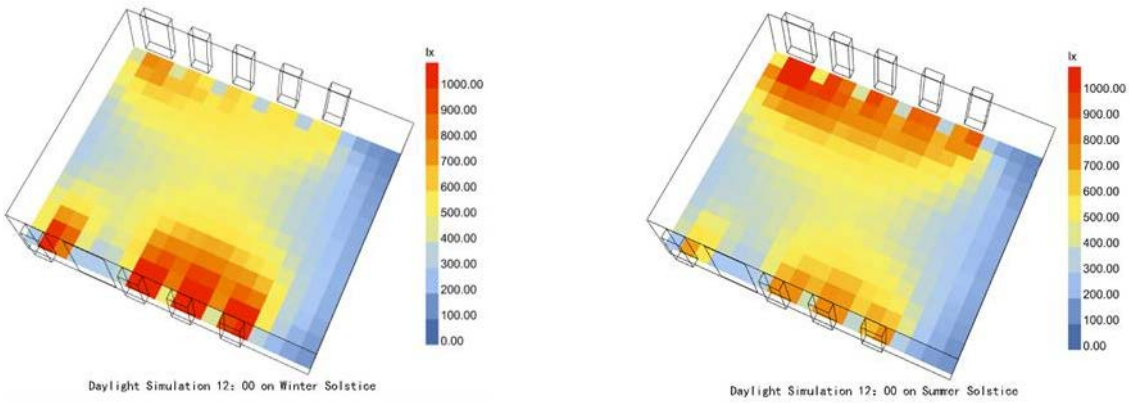


Figure 5. Indoor illuminance at 12:00 on the winter solstice and summer solstice in daylighting simulation (drawn by the author)

3.3. Glare analysis

Due to pandemic limitations, no physical field investigation of Gando Primary School was done. Hence, this study used the "image-free method" to simulate annual Daylight Glare Probability (DGP) and Glare Autonomy (GA) in the school's interior. The "image-free method" does not rely on field images during simulation and is a year-by-year simulation for glare caused by direct sunlight and sky. It depends on normalized coefficients (daylight coefficients) representing flux transfer from simulated sky patches to various observation positions with known direction and solid angle. DGP is calculated under specific sky conditions by applying sky luminance values of each patch, stored in a matrix with one column calculated per hour. The sky matrix contains 8,760 sky vectors per year, including nighttime sky vectors. Calculating daylight coefficients and sky matrix is faster than rendering images for each view under each sky condition with traditional glare calculation methods (e.g., UGR, DGI, CGI, and VCP).

When the DGP is below a threshold (e.g., 0.4), the glare was considered to be within an acceptable range in the space viewing direction. The specific DGP values and their corresponding degrees of glare-free space are shown in **Table 2**.

Table 1. DGP and glare-free space degree correspondence table

DGP	Degree of spatial glare
> 0.45	Unbearable glare
0.4–0.45	Dazzling glare
0.35–0.4	Perceived glare
< 0.35	Imperceptible glare

Given the DGP value vector of all occupied times in the given space viewing direction, we can define GA as the fraction of time without glare in that viewing direction. By setting a target for the maximum number of hours that DGP can exceed the threshold, we can also define the Glare Autonomy of space as the proportion of views in the space that achieve that target. Glare Autonomy provides us with a single value to summarize the degree of glare-free space.

The proportion of spaces that exceed 40% DGP within 5% of occupied hours was calculated. Conventional daylight autonomy abbreviates the Glare Autonomy of the 40% DGP threshold to GA40% and the corresponding spatial glare autonomy to sGA40%, 5%, with a target of 5% of occupied time. After L + H simulation calculations, the DGP distribution of Gando Primary School is shown in **Figure 6**, and the GA distribution of classroom units is shown in **Figure 7**.

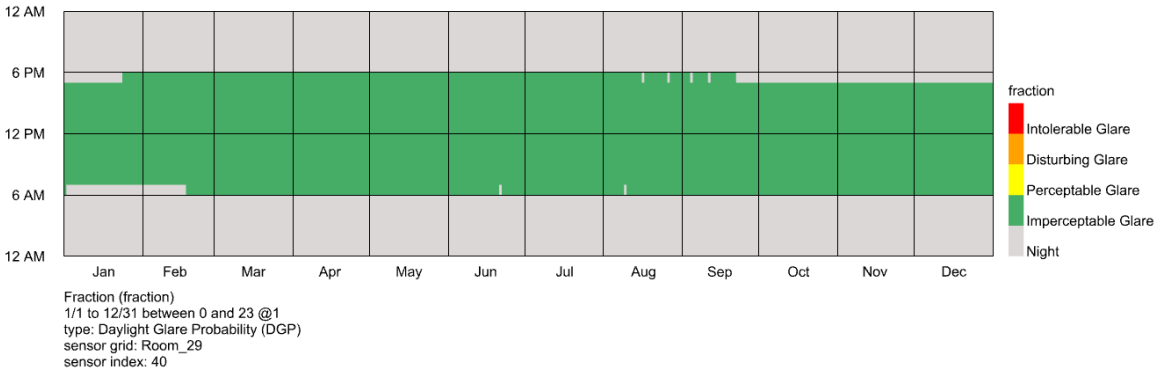


Figure 1. Distribution of daylight glare probability in Gando Primary School (drawn by the author)

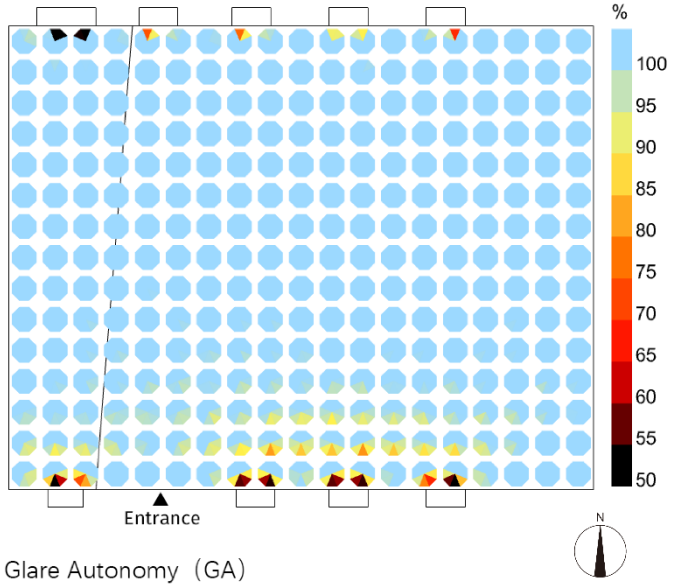


Figure 2. Distribution of glare autonomy in Gando Primary School classroom units (drawn by the author)

4. Evaluation of energy-saving effect of Gando Primary School L + H parametric

The light environment effect of the school's passive daylighting approach was evaluated for compliance with relevant standards through the light environment simulation analysis of Gando Primary School using the Ladybug + Honeybee toolchain. The simulation and calculation results show that the average indoor illuminance of Gando Primary School meets the daylighting standard of greater than 450lx and can satisfy the usage requirements for most of the year. The indoor planar illuminance distribution is relatively concentrated on the northern side and can meet the usage standards with the help of adjustable louvers. In terms of glare, the probability of glare occurrence in the interiors of Gando Primary School is less than 0.35 throughout the year, which is an imperceptible level of glare. The glare autonomy in most areas of the classroom units is lower than GA40%, indicating that spatial glare can be controlled at a relatively low level with no significant visual discomfort. In summary, the passive daylighting design of Gando Primary School is an effective daylighting strategy with a high level of natural daylighting capability.

Disclosure statement

The author declares no conflict of interest.

References

[1] Kéré DF, 2017, Gando Primary School. Architectural Worlds, 32(04): 12–15. http://doi.org/10.14080/j.aw.2017.04.002

[2] Zhang Z, 2022, Energy-saving Simulation Analysis of Kindergartens in Cold Regions Based on Ladybug+Honeybee Parametric Approach. Urban Architecture, 19(03): 45–49. http://doi.org/10.19892/j.cnki.csjz.2022.03.11

[3] China Academy of Building Research, 2013, Standard for Building Daylighting Design, GB 50033-2013, viewed February 11, 2023.

[4] Guo J, Sun Y, 2021, Building Energy-saving Daylighting Design and Evaluation Based on Ladybug-Honeybee: A Case Study of Guangzhou Science and Technology Library Project. Proceedings of the 2021 National Academic Symposium on Architectural Digital Technology Teaching and Research, 416–427.

[5] Mao P, Wang W, Li J, et al., 2018, The Impact of Indoor Illumination on Learning Efficiency in University Classrooms. Journal of Southeast University (Medical Edition), 37(04): 6–8.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Application Research of Sonar Detection Method in Melting Exploration at the Bottom of Piles

Tianzhi Liu[1], Ke Tu[2]*, Chunsong Duan[1], Qian Chen[1], Liu Hu Yan[1]

[1]Yunnan Infrastructure Investment Co.,Ltd., Kunming 650217, Yunnan Province, China

[2]China Merchants Chongqing Highway Engineering Testing Center Co., Ltd., Chongqing 400060, China

***Corresponding author:** Ke Tu, 406244561@qq.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Karst landforms are widely distributed in China, and are most common in Yunnan, Guizhou and Guangxi. If the development of karst caves at the bottom of the piles cannot be accurately ascertained before the construction of bridge pile foundations, accidents such as hole collapse, slurry leakage, and drill sticking will easily occur. In this paper, the principle and method of sonar detection for detecting karst caves at the bottom of bridge piles was introduced, and the sonar detection data and the cave situation at the bottom of the pile during the construction process in combination with the case of Yunnan Zhenguo Highway Project was analyzed, which verifies the practicability and reliability of sonar detection method reliability.

Keywords: Principle of sonar detection method; General situation of sonar detection method engineering

Online publication: July 28, 2023

1. Introduction

Karst, also known as karst landform, refers to the special landform and hydrogeology formed by soluble rock formations (mostly carbonate rocks, sulfate rocks, etc.) under the action of geological forces (especially the erosion of surface water and groundwater). Karst landforms are widely distributed around the world, and China is one of the countries with the most karst landforms. In China, places like Yunnan, Guizhou and Guangxi have the most karst landforms [1]. Karst areas often have irregular distribution and filling of karst caves, which will cause highly varied developments of the caves. The soil properties of the shallow soil surface do not meet the load-bearing and deformation requirements of shallow foundations, thus punching grouting or manual excavation piles are often used. Construction in karst areas without fully ascertaining the karst caves are very high risk, and serious accidents such as hole collapse, slurry leakage, ground subsidence, and drill sticking are prone to occur [2].

Therefore, before the construction of the pile foundation, detailed and accurate exploration of the karst cave at the bottom of the piles is required to avoid the above accidents during construction. Commonly used cave detection methods include high-density apparent resistivity method, shallow seismic method, bottom-penetrating radar method, advanced drilling method, elastic wave CT method, tube wave testing method, sonar detection method, etc. [3]. Among them, the resistivity method utilizes the different conductive properties of underground layers, and detects the distribution of geological layers according to the different conduction laws of current under the action of an external electric field [4]. The shallow seismic method utilizes the different characteristics of wave impedance between different geological layers, and detects information such as the position, size, and orientation of caves according to the different reflection waveforms of stress waves at different layers [5]. However, these two methods are difficult to use in mud,

and are not suitable for bored piles. If used for detection before drilling, they cannot accurately detect the position of the cave. The CT method uses elastic waves to project the geology, and calculates the position of the cave through the attenuation of elastic waves in different geological layers. However, this method requires at least two boreholes around the pile and is easily disturbed during detection [6]. As compared to the diameter of the pile, the diameter of the drilled hole by the advanced drilling method is too small, making it easy to miss the karst cave, moreover multiple drillings are time-consuming and laborious [7].

The commonly used methods are ground penetrating radar and sonar. The ground penetrating radar method uses the ground radar to emit high-frequency electromagnetic waves, and judges the condition of the cave through the amplitude, phase, and waveform of the reflected waveforms between different geological layers. However, the ground penetrating radar method is mostly used for piles before drilling or manual excavation, and is not suitable for mud [8]. The sonar detection method can utilize mud as a coupling agent, making it an interference medium to propagate sound waves. This allows the waves to go deep into the pile diameter hole during the construction stage and directly conduct close-range and high-precision detection at the bottom of the piles. This method can be applied to both manual excavation piles and bored piles [9].

Based on the newly-built highway in Zhenxiong, Zhaotong, Yunnan, the sonar detection method is used for the new pile foundation. Through the comparison of the collected data of sonar detection method and ground penetrating radar method, the applicability and accuracy of the sonar detection method were verified.

2. Principle of sonar detection method

2.1. Sonar detection method

Sonar detection method works by emitting sonar stress waves. According to different impedances between different soil layers, sonar waves have different amplitudes and strengths when passing through different layers, which provides data about the direction of pile bottom culverts and other information. During on-site detection, the electrical signal emitted by the host is first converted into an acoustic signal by the sonar transducer and emitted vertically downward. The acoustic signal then travels down through the mud and bedrock. Because the resistivity of caves or weak interlayers under the bedrock is different from that of the bedrock, sonar signals generate strong reflection waves. Finally, the reflected waves are received by the three receiving probes around the transmitting probe, as shown in **Figure 1**. The pitch and roll angles of the three receiving probes are measured by the three-dimensional electronic compass in the probe to ensure that the sound wave signal is transmitted to the surrounding rock at the bottom of the piles as vertically as possible. The receiving transducer converts the acoustic signal into an electrical signal and transmits it to the on-site host for display, analysis and storage [9]. The detection process is shown in **Figure 2**.

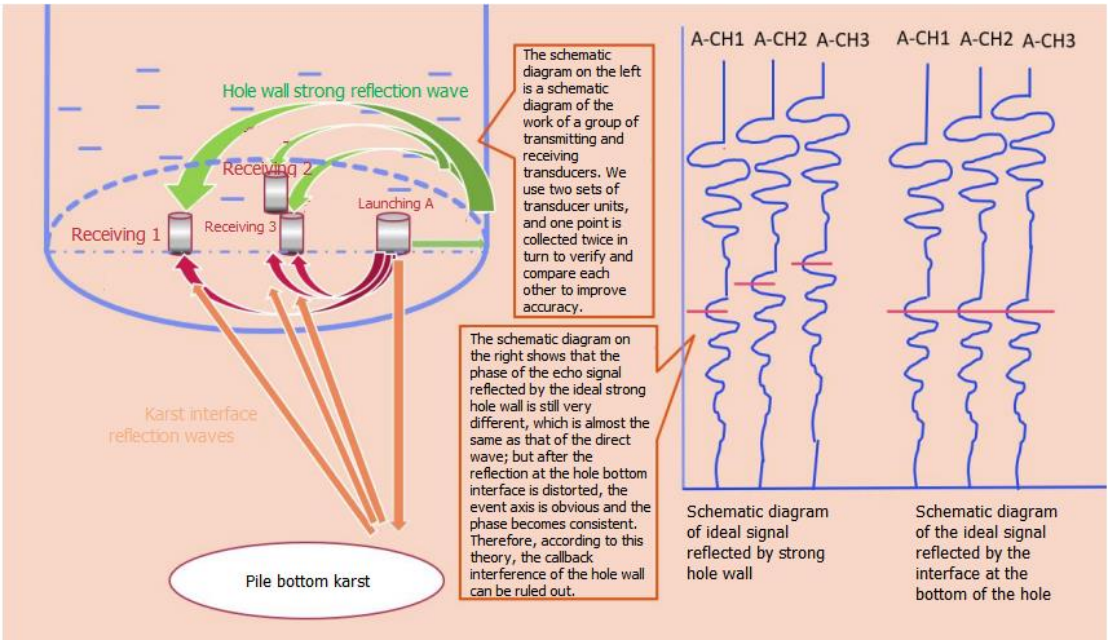


Figure 1. Schematic diagram of sonar detection method

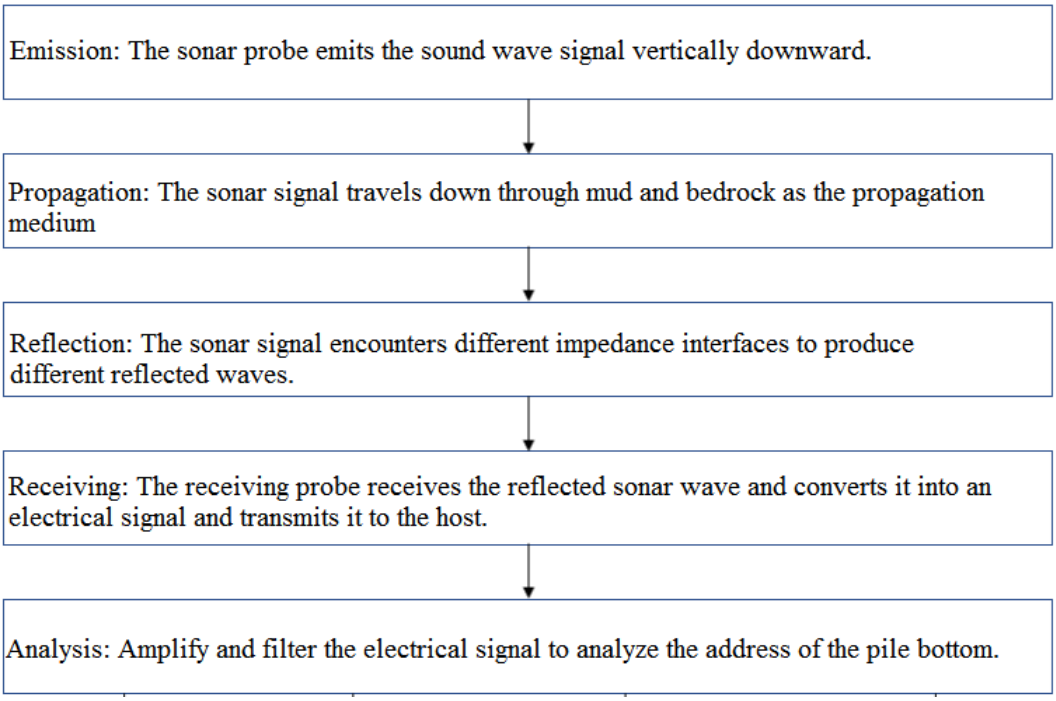


Figure 2. The detection process of the sonar detection method

2.2. Sonar detection theory

Because the distance between the transmitting probe and the receiving probe of the sonar detector is relatively close, it can be regarded as a very small offset. Therefore, one-dimensional wave theory [10] can be used for analysis. Its theoretical vibration equation is as follows:

$$\frac{\partial^2 u}{\partial t_2} = C^2 \frac{\partial^2 u}{\partial x_2} \tag{1}$$

where u represents the particle vibration position, t represents the time, x represents the particle vibration direction, and C represents the wave propagation velocity of the particle in the x direction. From calculations of Equation (1), a D'Alembert's solution like Equation (2) can be obtained to show that the vibration of the particle is the superposition of two reverse waves:

$$u(x,\ t) = f(x - Ct) + g(x + Ct) \tag{2}$$

assuming that $f(x - Ct)$ is the downward-firing sonar stress wave and $g(x + Ct)$ is the reflected wave from different interfaces. They maintain the original waveform, propagate and superimpose with speed C. When the sonar stress wave encounters soil interface with different properties above and below, the stress wave will be refracted and reflected. Its reflection must have equal stress on both sides of the interface and continuous particle velocity. This can be reflected as Equation (3) and (4):

$$P + P_R = P_T \tag{3}$$

$$v - v_R = v_T \tag{4}$$

where P, P_R, P_T represents the incident, reflected, and transmitted sound pressures respectively, and v, v_R, v_T represents the incident, reflected, and transmitted wave velocities respectively. Equation (5) can be obtained by substituting $v = P/Z$ into Equation (4), where Z is the wave impedance of the medium and can be represented as $Z = \rho C$:

$$\frac{P}{Z_{top}} - \frac{P_R}{Z_{bottom}} = \frac{P_T}{Z_{bottom}} \tag{5}$$

By solving Equation (3) and (5) simultaneously, Equation (6) is obtained:

$$R = \frac{P_R}{P} = \frac{Z_{bottom} - Z_{top}}{Z_{bottom} + Z_{top}} \tag{6}$$

where R is the reflection coefficient, which represents the difference in wave impedance between soil layers, indicating the situation at the bottom of the pile. The greater the absolute value of R, the greater the difference in wave impedance between the upper and lower media. As shown in **Table 1**.

Table 1. Reflection coefficient reflects bedrock conditions

R > 0	R < 0	R = 0 and the signal energy is strong	R = 0 and the signal energy is weak
Bedrock is soft at the top and hard at the bottom	Cave development	Bedrock intact	Bedrock shattering

When the bedrock at the bottom of the pile is complete, the sonar stress wave does not undergo secondary reflection, that is, R = 0, and the signal energy is strong. Ideally, the time-domain curve of the reflected wave received by the sonar receiving probe decays exponentially, and the amplitude decays uniformly. When there is a karst cave at the bottom of the pile, because the wave impedance of the filling in the karst cave is smaller than that of the bedrock at the top of the karst cave, that is, R < 0, the phase of the reflected wave is opposite to that of the incident at the bottom of the pile, and a quadratic wave impedance will appear on the time domain curve. Reflection, superimpose the reverse bit waveform at the cave development. When there is a harder rock layer at the bottom of the pile that is soft at the top and hard at the bottom, the density of the rock medium in the lower layer is higher, and its wave impedance is greater than that of the upper bedrock. At this time, R> 0, and the phase of the reflected wave at the interface is the same as that of the incident at the bottom of the pile. The reflected waves are the same, shown on the time domain curve as positive phase waveform superposition. When the rock formation at the bottom of the pile is broken, the bedrock at the bottom of the pile does not have a clear and complete reflection surface, at this time R = 0 but the signal energy is weak. The signal received by the sonar receiver is much weaker than when the bedrock is intact [10].

2.3. Sonar detection device

The sonar detector used in this paper is JL-SONAR(B), which includes a field host for controlling the probe and analyzing data, a cable connecting the host and the probe, and a sonar probe. Wherein the sonar probe includes a microcomputer, a transmitting probe, a receiving probe and a three-dimensional electronic compass. The micro-computing realizes the transmission and control of each instruction. The three-dimensional electronic compass is installed horizontally in the sonar probe to measure the azimuth and inclination angle of the probe. The transmitting power of the transmitting probe can reach 10 kW, and the transmitting frequency band is 200 Hz to 8 kHz. The detection accuracy is ensured by high-frequency emission, and the high-frequency part is not rapidly attenuated by high power. The detector is shown in **Figure 3**.

Figure 3. Sonar detector

3. Engineering example of sonar detection method

3.1. Project overview

Zhenxiong County is located in the hinterland of Wumeng Mountain, where roads are the main means of transportation. The Zhenxiong-Guozhu Railway Station-Dawan Highway Project is located in Zhenxiong County, Zhaotong City, Yunnan Province. The terrain where the railway line passes has large ups and downs, varies greatly and is very complex. It is dominated by karst landforms, which can be classified according to their origin and morphology into denuded low-middle level landforms, erosive accumulation landforms, and tectonic dissolution low-middle mountain landforms. On the other hand, the fractures in the rock joints of the middle mountain landform with low tectonic dissolution are extremely developed, and

the rock mass is severely broken. Therefore, the flow of groundwater is complicated, which provides good conditions for the development of karst caves. Moreover, the expressway crosses many rivers and valleys, so the scale of the bridge is relatively large. The piers and abutments under the bridge are mainly based on pile foundations, and most of the pile foundations are stressed by the pile tip resistance. Therefore, there is a strong demand for detection of the development of karst caves at the pile bottom. It is necessary to detect whether there is a karst cave within three times the pile diameter below the under pile and not less than 5 m.

3.2. Complete typical data of pile foundation surrounding rock

The detection results of a pile foundation on Zhenxiong Highway are shown in **Figure 4**. The pile foundation was an end-bearing pile, and the impact hole was used. The designed pile length was 27.0 m and the pile diameter was 1.8 m. From the detection data in **Figure 4**, it can be seen that the reflected waveform of the pile foundation was regular, and the overall attenuation was normal. It can be seen that R = 0, and the signal energy was strong. Based on this, it was inferred that the surrounding rock at the bottom of the pile foundation was complete, and the bearing capacity of the surrounding rock was relatively high. No karst caves have been found within the range below the pile bottom elevation of 6m. It was recommended to proceed to the next step.

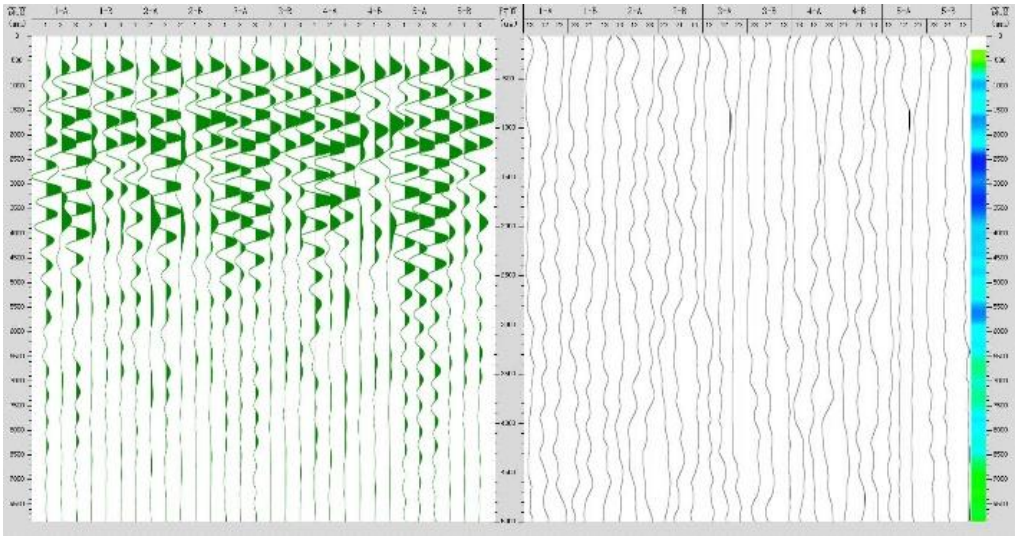


Figure 4. Detection results of an impact-drilled end-bearing pile foundation on Zhenguo Highway

3.3. Typical data of fissure development in pile bottom surrounding rock

The detection results of a pile foundation on Zhenguo Highway are shown in **Figure 5**. The pile foundation was a rock-socketed pile, which was drilled by impact. The designed pile length was 20.0 m and the pile diameter was 1.6 m. From the detection data in **Figure 5**, it can be seen that the waveform of the pile foundation was regular, the attenuation was relatively normal, and a weak positive phase high-frequency reflection signal appeared within the range of 1.5 m to 2.5 m of the pile bottom elevation. It can be seen that at this time R > 0, the bedrock at the pile bottom was soft at the top and hard at the bottom. Based on this, it was speculated that the surrounding rock at the bottom of the pile foundation has local cracks and weak interlayers, and no karst caves have been found within 5.0 m below the pile bottom elevation. Moreover, the positive phase reflection of the pile foundation waveform was weak, and the weak interlayer had little influence on the bearing capacity of the surrounding rock at the bottom of the pile. It was recommended to proceed to the next step.

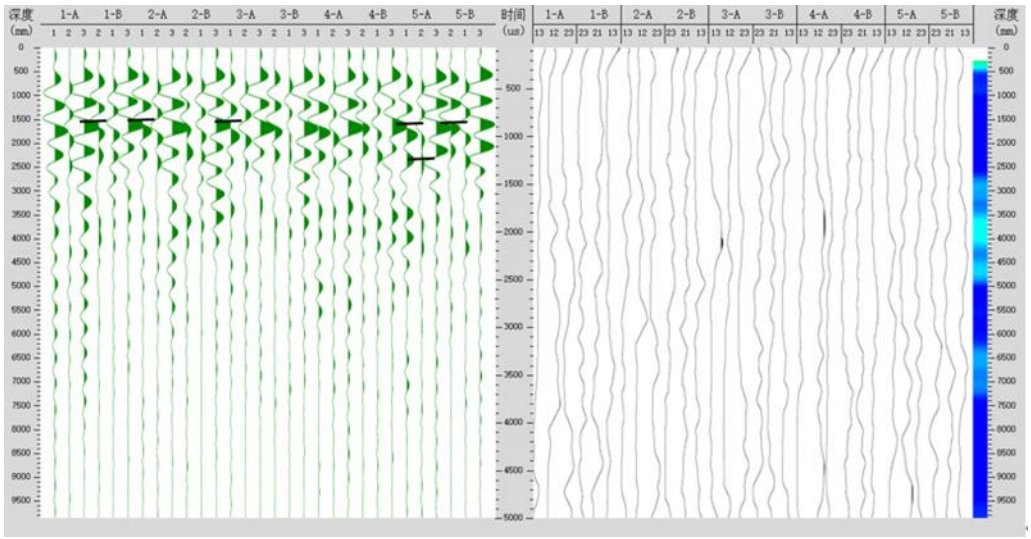


Figure 5. Detection results of an impact-drilled rock-socketed pile foundation on Zhenguo Highway

3.4. Typical data of pile bottom surrounding rock crushing

The detection results of a pile foundation on Zhenguo Highway are shown in **Figure 6**. The pile foundation was a rock-socketed pile, which was manually dug. The designed pile length was 20.0 m and the pile diameter was 1.6 m. From the detection data in **Figure 6**, it can be seen that the waveform of the pile foundation was irregular and the attenuation was abnormal. There were obvious random reflection signals in the range of 2.0 m to 3.0 m at the bottom of the pile, and the waveform energy was weakened below 5.0 m. It can be seen that $R > 0$, and the energy signal weakened significantly. Based on this, it was speculated that the surrounding rock at the pile bottom in the range of 2.0 m to 3.0 m below the pile bottom elevation of the pile foundation is relatively broken, but it has little impact on the load capacity of the pile bottom surrounding rock. No karst caves were found within 5.0 m below the pile bottom elevation. It was recommended to proceed to the next step.

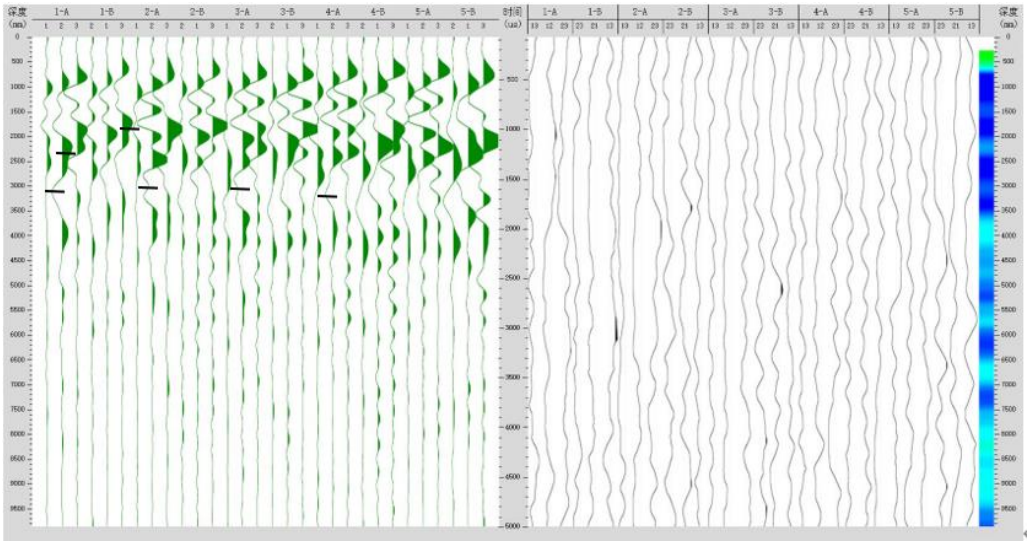


Figure 6. Detection results of a manually dug rock-socketed pile foundation on Zhenguo Highway

3.5. Typical data on the development of karst caves in surrounding rocks at the bottom of piles

The detection results of a pile foundation on Zhenguo Highway are shown in **Figure 7**. The pile foundation was end-loaded, and impact holes were used. The designed pile length was 18.0 m and the pile diameter was 2.2 m. From the detection data in **Figure 7**, it can be seen that the frequency of the pile foundation

detection waveform data was low, the waveform was irregular, and the attenuation was abnormal. In the southwest direction of the pile bottom, there were strong low-frequency reflection signals and strong negative phase reflection signal, which show that R < 0 at this time. Based on this, it was speculated that karst caves have occurred within the range of 1.5 m to 2.5 m below the southwest elevation of the pile foundation. It was suggested that the pile foundation should be deepened by 2.5 m to pass through the cave. During the deepening process, due to the existence of caves, there was a slurry leakage situation. This also proves the accuracy of the sonar detection method.

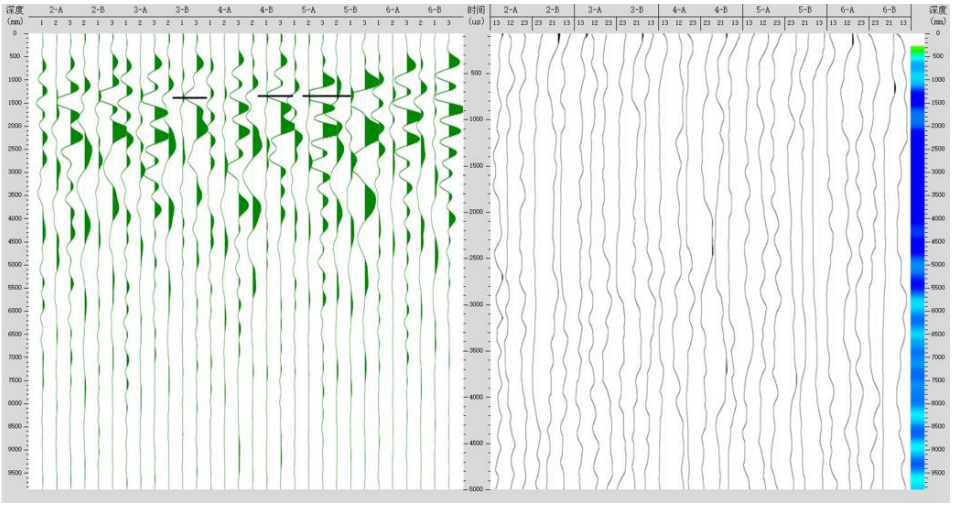


Figure 7. Detection results of an impact-drilled end-loaded pile foundation on Zhenguo Highway

After the pile foundation was deepened by 2.5 m, retesting was carried out, and the results are shown in **Figure 8**. At the time, the actual excavation depth was 22.30 m. From the detection graph, it can be seen that the abnormal points were significantly reduced after the pile foundation was deepened, the waveform was relatively regular, and the attenuation was basically normal. It can be seen that R = 0 at this time, and the signal energy was strong. In the range of 2.0 m to 3.0 m below the southern elevation of the pile bottom, the waveform signal was weak, and it can be seen that R = 0 at this time, and the signal energy was weak. Based on this, it is inferred that local cracks were developed in the rock strata within 2.0 m to 3.0 m below the southern elevation of the pile foundation, and the pile base rock is relatively complete in other positions. No karst caves have been found 8 m below the pile bottom.

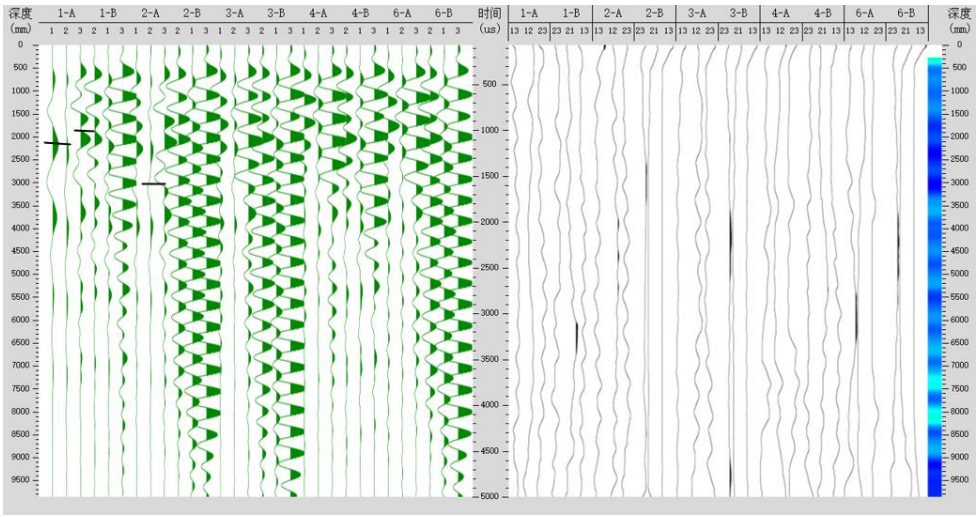


Figure 8. The detection results of a pile foundation deepened by 2.5 m on Zhenguo Highway

The detection results of another pile foundation on the Zhenguo Highway are shown in **Figure 9**. The pile was a rock-socketed pile, which was manually dug. The designed pile length was 20.0 m and the pile diameter was 1.6 m. From the detection data in **Figure 9**, it can be seen that the waveform of the pile bottom of the pile foundation was irregular, the attenuation was abnormal, and a strong low-frequency negative phase reflection signal appeared within the range of 1.5 m to 3.0 m of the pile bottom elevation. It can be seen that $R < 0$ at this time, the surrounding rock at the bottom of the pile was hard at the top and soft at the bottom, and the signal energy was weak. Based on this, it was speculated that the suspected karst caves developed within the elevation range of 1.5 m to 3.0 m southwest of the pile bottom of the pile foundation, and the surrounding rock at the pile bottom was severely broken within the range of 1.5 m to 3.0 m at the pile bottom. It was recommended to deepen the tunnel by 3.0 m.

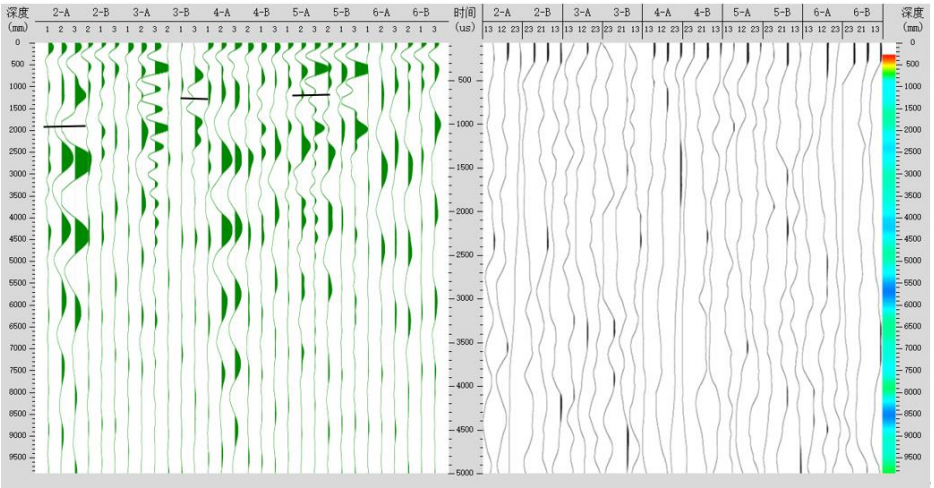


Figure 9. Detection results of another pile foundation on Zhenguo Highway

The slag sample at the bottom of the pile manually excavated is shown in **Figure 10**. The order of the slag samples is that the slag sample box is sorted from left to right, from top to bottom, and each grid represents 1 meter of slag samples. It can be seen from the slag sample diagram that the pile bottom of the pile foundation was mainly composed of silty clay, and the soil quality of the pile bottom is shown in **Figure 11**. It can be seen that the bottom of the pile was still dominated by silty clay mixed with gravel, and the surrounding rock at the bottom of the pile was severely broken, which also verifies the accuracy of the sonar detection method.

Figure 10. Slag sample at pile bottom

Figure 11. Soil sample at pile bottom

The detection results after the pile foundation was deepened by 3.0 m is shown in **Figure 12**. From the detection data in the figure, it can be seen that the abnormal points of the pile foundation were reduced, but the signal energy was weak, and the waveform attenuation can be found. It can be seen that at this time

R = 0, the signal energy was weak, and it is speculated that the surrounding rock at the bottom of the pile was broken. However, there were no caves, and the fracture was not serious and can still be used as a bearing layer.

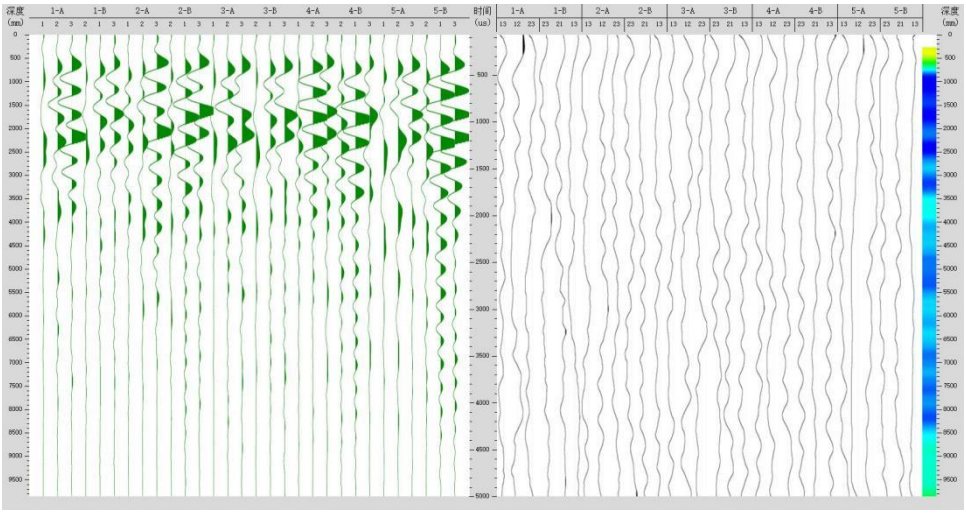


Figure 12. The detection results of a pile foundation deepened by 3 m on Zhenguo Highway

4. Conclusion

4.1. Advantages of sonar detection

The sonar detection method does not require advanced geological drilling, and the operation method is simple. It does not need to drill holes in advance, and can complete pile-by-pile detection. The detection cost is low, and the detection results are accurate and reliable. It overcomes the shortcomings of other detection methods, such as complicated operation, high cost, and inaccurate detection.

In addition, mud in bored piles may hinder other detection methods and affect the accuracy of detection results. The sonar detection method uses mud as the coupling medium, and the acoustic impedance of the mud is closer to the rock, which can improve the acoustic coupling rate, so that more acoustic energy can be transmitted into the bedrock at the pile bottom.

4.2. Disadvantages of sonar detection

Although the sonar detection method can detect the condition of the surrounding rock at the bottom of the pile and determine whether there are karst caves developed, the signal gradually weakens due to the increase of the sound wave signal with the depth of the surrounding rock. When the depth of the cave is deep, the height of the cave cannot be accurately detected, and the specific development conditions such as the width and filling status of the cave cannot be accurately measured through a single point. There is also a need to continue to improve detection techniques.

In the artificial excavated pile, because of the lack of mud as the coupling medium, the sonar energy in the artificial excavated pile cannot be well transmitted to the bottom of the pile, resulting in weak acoustic reflection signals received.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Yang Y, Liu H, Huang X, et al., 2022, Analysis of DC Resistivity Anomaly Characteristics and Research on Terrain Correction Method under Complex Terrain Conditions. Hongshuihe, 41(06): 118–123.

[2] Wu Q, Yao X, Chen X, et al., 2022, Research on Non-destructive Detection Method of Soil Configuration based on Ground Penetrating Radar. Arid Region Geography, 45(06): 1860–1869.

[3] Gao J, Zhou T, Du W, et al., 2022, Research on Multi-echo Detection Method of Multi-beam Bathymetric Sonar based on Phase Feature. Journal of Instrumentation, 43(08): 193–203. http://doi.org/10.19650/j.cnki.cjsi.J2209721

[4] Song Y, 2022, Application of Shallow Seismic Reflection Wave Method in Site Selection and Investigation of Road Engineering. Metallurgical Management, 2022(07): 115–117.

[5] Peng Z, Song W, 2021, Research on Construction Technology of Pile Bottom Exploration and Dissolution in Karst Landform. Traffic World, 2021(23): 163–164. http://doi.org/10.16248/j.cnki.11-3723/u.2021.23.068

[6] Fang Y, Wu Z, Sheng Q, et al., 2020, Intelligent Identification Method of Tunnel Stratum Based on Advanced Drilling Test. Rock and Soil Mechanics, 41(07): 2494–2503.

[7] Zhou K, Wang H, 2018, Application of Cross-hole CT Method in Pile Foundation Spacing Detection in Subway Engineering. Tunnel Construction (Chinese and English), 38(05): 747–752.

[8] Liu C, Shi Z, Liu L, et al., 2017, A Review of Pile Karst Detection Methods in Complex Karst Areas. Proceedings of the 15th National Academic Conference on Engineering Geophysical Prospecting and Geotechnical Engineering Testing, 11–17.

[9] Shi Z, Liu L, Peng M, et al., 2016, Sonar Detection Method and Application Research on Karst Caves at the Bottom of Bored Piles. Journal of Rock Mechanics and Engineering, 35(01): 177–186. http://doi.org/10.13722/j.cnki.jrme.2015.0125

[10] Shi X, 2005, Study on the Roof Stability of Hidden Karst Cave Under Pile Foundation Load in Karst Area, dissertation, Graduate School of Chinese Academy of Sciences (Wuhan Institute of Rock and Soil Mechanics).

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Function Analysis of Urban Rail Transit Smart Station

Can Chen*

Chongqing Energy College, Chongqing 402260, China

***Corresponding author:** Can Chen, 422209918@qq.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: In order to make rail transit smart stations serve passengers better, the potential of smart stations should be optimized to reduce time cost, and relieve traffic congestion. In this paper, the construction of smart stations based on the management experience of a subway station and the benefits of smart stations were analyzed and discussed. The construction of smart stations, as well as the key technologies for the construction of smart stations, will aid in the automation and intelligent management of subway stations.

Keywords: Urban rail transit; Smart station; Function analysis

Online publication: July 28, 2023

1. Introduction

During the initial stage of the development of urban rail transit in China, traditional computer control systems were mainly used in subway stations, the information and facilities in the stations were also managed manually. At the time, computer system applications had lower standard, thus the station management functions and station operation organization was also relatively backward. With the increase of subway operating lines and the continuous expansion of the functional requirements of subway stations, the automation and intelligent management of subway stations have become more popular. The rapid development of computer and communication technology promoted the use of various smart devices in the stations. Subway stations have also begun to adopt facilities and equipment such as intelligent lighting, intelligent security, intelligent comfort service, intelligent entertainment system, and intelligent passenger flow statistics and analysis. Through the use of various facilities, passengers can share and exchange information with the subway operation and dispatch center [1-6]. At present, many cities in China have begun the construction of smart transportation systems in urban rail transit networks. In order to better improve customer service, more stations will need to adopt the practice of intelligent management and make good use of these intelligent facilities and equipment.

2. Smart station

The current trend of urban rail transit construction is the construction of smart stations. With the continuous development of urban rail transit, the use of various equipment and facilities will also increase, which will lead to the development of smart stations. Smart station refers to the intelligent and automatic management of subway stations based on new technology, where the information sharing between intelligent systems is achieved through network transmission [7-11]. The construction of smart stations can be done using various methods, which can be analyzed as such:

2.1. Based on existing equipment

Currently, many kinds of equipment are being used in China's subway stations, however most of them are designed on the basis of traditional computer control systems. With the advancement of science and technology, this kind of equipment can no longer meet the needs of modern subway operation and management. Therefore, when constructing a smart station, the existing equipment can still be used as the basis, but upgraded and transformed when necessary. This method can not only effectively reduce costs, but also help improve the level of smart station construction (**Figure 1**).

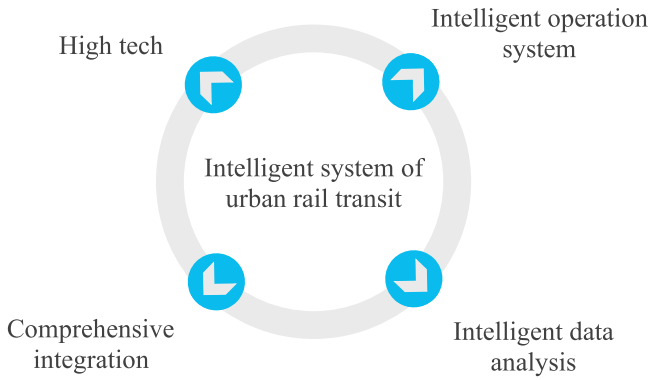


Figure 1. Urban rail transit smart system

2.2. Focusing on software development

Currently, various kinds of computer control systems and communication systems are being used in China's subway stations, however these systems cannot keep up with the standard of China's subway industry development. When building smart stations, software development should be the core focus, only when the software development is successful can the subway management and control functions be achieved.

2.3. Using the computer network as the platform

Currently, most of the computer control systems used in China's subway stations are connected via local area network or wide area network with external communication systems through the Ethernet. In the construction of smart stations, the computer network should be used as the platform, and the existing communication means should be used to exchange and share data. This allows the informatization, intelligence and networking of the subway operation management. Moreover, virtual reality technology is the current new emerging technology in China. It combines various equipment systems with computer network technology, and can simulate equipment systems through virtual reality technology. In this way, functions such as monitoring, management and maintenance of subway operation equipment can be achieved, and users can remotely operate and control subway equipment.

2.4. Using big data analysis

Currently, the equipment systems used in China's subway stations are usually managed manually, however due to the lack of scientific and logical management methods by managers, problems such as low management efficiency and waste of resources have emerged. Therefore, during the construction of smart stations, big data analysis should be used as a means to carry out intelligent and automatic management along with scheduling management of equipment systems.

2.5. Customer service satisfaction as priority

With the development and progression of society and economy, people have begun to hold higher standards for subway travel. Therefore, during the construction of smart stations, customer service satisfaction should be the prioritized, and existing resources should be fully utilized for functional development and intelligent design [12].

According to the analysis above, a variety of methods and technical means should be included in the construction of smart stations to keep up with society's development.

3. Construction of smart stations

3.1. Intelligent lighting

LED lighting is energy-saving, environmentally friendly, and has a long lifespan of more than 15 years, thus it should be used to illuminate the stations. The intelligent lighting system of the station can be divided into two parts: ambient lighting and equipment lighting. Ambient lighting can be used to light up public areas in the stations, such as station halls and platforms whereas equipment lighting can light up equipment rooms in stations.

3.2. Intelligent security

The number of passengers has gradually increased with the development of the urban rail transit network. In order to ensure the safety of passengers, equipment such as escalators and vertical elevators have also been installed at stations. By installing automatic emergency braking system (AES) in escalators and vertical elevators, passengers can pass through the platform safely and quickly during emergency situations. Since the system is installed according to the number of passengers and the direction of travel, its installation location is also different. Under normal circumstances, the station only needs to install one AES in the station hall to meet the safety needs of passengers. In case of emergency, the device can be operated through the manual button panel installed in the station hall. As for the vertical elevator, due to its complex structure, it has a higher requirement for the platform layout, so the system would be set in the platform area between the first basement and the second basement.

3.3. Intelligent comfort service

Since there are equipment and facilities such as escalators and vertical elevators in the station, by installing corresponding sensors and controllers on these equipment, real-time monitoring and statistical analysis of the number of passengers can be done. At the same time, installing facial recognition equipment in the stations allows the identification of passengers, which can help with the recording of passenger information. Information such as current passenger flow, boarding, and landing situations in the station can be fed back to passengers in real time after being collected via the facial recognition equipment.

3.4. Intelligent entertainment system

There are multiple public entertainment areas and vending machines in the station. Remote control of these equipment and facilities can be achieved through wireless controllers or wireless network equipment that are set up in the station [13]. At the same time, these equipment and facilities can also provide passengers with entertainment and convenient services.

3.5. Intelligent passenger flow statistics and analysis

The stations can adopt an intelligent passenger flow statistical analysis system based on mobile Internet technology. Through this system, the real-time collection and statistical analysis of the number of passengers in the subway station and the situation of passengers entering and leaving the station can be

achieved. At the same time, the system can also provide effective data support as a decision-making basis for subway operating companies. Currently, the stations already have relatively complete intelligent equipment and systems, and its functions and performance are also being continuously improved.

4. Key technologies

4.1. Information system for passengers

To solve the issue of lack of information due to the absence of guidance devices, the first thing that could be done is to establish a notification and announcement system. The original passenger information system can be remained, and the new notification system should be installed for the background management platform and front-end equipment terminals. These platforms can access a unified platform of smart stations for equipment status and data, and accept real-time instructions from the intelligent platform, to achieve an inter-system interaction.

To further provide information for passengers, an intelligent light indication management system could be implemented. Not only can this system provide status reporting while interacting between systems, it can also be remotely managed in real-time to control the display and lighting effects when needed.

Another method to improve the information system for passengers is the real-time guidance system. In this system, there is an independent camera set up at each exit to obtain real-time images. 4 sets of real-time guidance screens should be set up in the paid area (area with boom where gates parking fee is needed) and free areas (the area without boom gates where no parking fee is needed) to help passengers understand the route. The behind-the-scenes management system should work to manage the equipment, process the collected information, and use AR enhancement to analyze the data that cannot be obtained. The data can then be displayed for the passengers on the screen.

A guidance system is installed on the doors to guide passengers. It includes a back-end management platform and a front-end display system.

4.2. Intelligent security check

The X-ray security detector will collect video recordings of passengers' baggage and the original baggage inspection data, then the intelligent analysis instrument will identify whether there is any illegal or prohibited items in the baggage. The body temperature detection door will also help collect passenger data like facial recognition, body temperature, whether the passenger is carrying metal items, etc. The system collects the relevant data from baggage inspections even when an employee gets off their shift, forming a complete closed loop in the detection process. In addition, the security inspection machine can also be used for data collection, storage, upload of personnel data, equipment data, business data, etc.

The multi-dimensional information obtained can then be used as a foundation in order to improve the subway safety inspection process to meet the set requirements. Various types of safety inspection services can be done (personnel management, equipment management, event management, etc.) to improve the effectiveness of the entire rail transit safety inspection service management.

4.3. Intelligent operation management system

The intelligent operation management system is the main component of a smart station. It is a comprehensive command platform for the station's daily operation, employee management, emergency management, resource management, and deployment management. This system integrates the sensor data, equipment status data, fault data, and human error data of each main equipment, and allows the remote control of each subsystem and sub-module. Based on lightweight Building Information Modelling technology, a three-dimensional interactive platform can be built to comprehensively display the location and detection information of important mechanical and electrical devices such as personnel location, crowd

density distribution, environmental control, fire protection, gate control, and alarm information, and job information.

4.4. Hyperconverged infrastructure construction

During the construction of a hyperconverged infrastructure for the smart station, we configured the 4-node hyperconverged all-in-one machine and built a software-defined computing, storage, and network resource pool to transfer the main business applications to a hyperconverged platform. Management hyperconvergence refers to an automated hyperconverged management platform, which can conduct unified management of resources such as computing, storage, network and security, including virtual machines, storage and other advanced attributes. Furthermore, the relevant information can be displayed on a big screen, which allows users to have a better understanding about the resource usage status of the hyperconverged cluster. It can also customize and monitor the status of the business virtual machines.

The collaboration of various systems will lead to a stable and efficient operation of smart stations. If the inter-system collaborative interaction cannot be formed, the true potential of smart stations cannot be reflected. Therefore, it is necessary to conduct in-depth research on the characteristics of each system, clarify their internal relations, and use the network as the basis to achieve an efficient and functional connection, so that the functions of smart stations can be utilized to the greatest extent.

5. Conclusion

With the rapid development of China's urban rail transit, the scale of the stations has expanded which increased the stations' functional requirements and passengers have begun to hold higher expectations for customer service quality. The main issue here is how to organically combine the construction of smart stations with the operation and management of subways in a refined manner. It requires the joint participation of subway operation and management departments, rail transit construction units, and equipment suppliers. When all necessary units can cooperate in the project construction process, the intelligence level of subway operation management be improved. As a response, the operation efficiency and passenger satisfaction of the subway operation can be improved. This is one of the important factors for the development of smart transportation in the future.

Disclosure statement

The author declares no conflict of interest.

References

[1] Luo C, 2022, Collaborative Management Mode and Technology Application of Urban Rail Transit Stations. Digital Technology and Application, 40(12): 74–76.

[2] Chen X, 2022, Scene Linkage Design of Urban Rail Transit Smart Station Comprehensive Transportation Management Platform. Modern Urban Rail Transit, 2022(12): 83–87.

[3] Liu S, Zhang J, Wang W, 2022, Research on Functional Requirements of Rail Transit Smart Stations. Journal of Zhengzhou Railway Vocational and Technical College, 34(04): 27–29.

[4] Fang Y, 2022, Research on Intensive Arrangement Scheme of Urban Rail Transit Smart Station Facilities and Equipment. Modern Urban Rail Transit, 2022(06): 17–20.

[5] Chen K, Xu B, 2022, Construction and Implementation of Urban Rail Transit-Smart Stations. Metallurgical Automation, 46(S1): 198–199.

[6] Wang Y, 2022, Analysis of Smart Station Business. Inner Mongolia Science and Technology and

Economy, 2022(05): 63–64.

[7] Zhang W, 2021, Functional Requirements Analysis of Urban Rail Transit Smart Stations. Electronic Technology, 50(12): 260–261.

[8] Wu M, 2021, Discussion on the Functions of Urban Rail Transit Smart Stations. Modern Urban Rail Transit, 2021(07): 15–21.

[9] Zhou G, 2021, Research on the Theory and Method of Short-term Passenger Flow Forecasting of Urban Rail Transit under Multiple Scenarios, dissertation, Beijing Jiaotong University.

[10] Zhou M, 2021, Research on Smart Station Construction of Urban Rail Transit. Locomotive Electric Transmission, 2021(03): 118–124.

[11] Guo X, 2020, Prospect Analysis on the Development of Smart Stations in Urban Rail Transit. SME Management and Technology (Mid-day Journal), 2020(07): 124–125.

[12] Liu L, 2019, Invulnerability Analysis of Urban Rail Transit Network Structure and Function Based on Failure of Important Stations, dissertation, Beijing Jiaotong University.

[13] Li A, Zhang F, 2009, Analysis of the Realization of IBP Panel Functions in Urban Rail Transit Stations. Modern Urban Rail Transit, 2009(01): 10–12.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Research on the Reform of the Course "Reading of Concrete Structure Plan and Construction Drawings" Under the Background of "Promoting Teaching and Learning Through Competitions"

Guixiang Yu[1]*, Xiaolong Tan[2]

[1]Chongqing Energy College, Chongqing 402260, China

[2]CCTEG Chongqing Engineering (Group) Co., Ltd., Chongqing 402260, China

***Corresponding author:** Guixiang Yu, 281659859@qq.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The inherent teaching approach can no longer meet the demands of society. In this paper, current issues within the teaching landscape of architectural engineering technology in higher vocational colleges as well as the policies and teaching demands that formed the basis of this model were analyzed. The study shows the importance of the implementation of the teaching model "promoting teaching and learning through competitions." This model puts emphasis on the curriculum and teaching resources, while also integrating the teaching process and evaluation with competition. These efforts aim to drive education reform in order to better align with the objectives of vocational education personnel training, while also acting as a reference for similar courses.

Keywords: Promoting teaching through competitions; Promoting learning through competitions; Reading of concrete structure plan method construction drawings; Course reform

Online publication: July 28, 2023

1. Introduction

Construction engineering technology is currently a popular subject in China's higher vocational education. It offers a wide range of employment opportunities, primarily in the field of civil engineering construction and management. For engineers, the ability to interpret architectural drawings is a fundamental skill which enhances the competitiveness of graduates in the workplace. Currently, most municipal buildings in China use reinforced concrete structure as the building load-bearing structure. Moreover, due to the increasing shortage of land and improvement of construction standards, building structures have become increasingly complex, which means its construction drawings have also become more complicated. Among architectural construction drawings, structural construction drawings are the ones that engineers come into contact with the most and are also the most difficult to comprehend. Therefore, it is necessary to be able to properly read concrete structure construction drawings.

Currently, there are still many shortcomings in the teaching of the course "Reading of Concrete Structure plan and plan Construction Drawings" in China. As China's vocational education system continues to evolve, the focus of the development of China's vocational education has also changed. The development of vocational colleges has become a major issue which has to be solved urgently. In the

process of educational reform, the curriculum and mode of teaching are the main starting points, and the approach of "promoting teaching and learning through competitions" should be employed to improve the quality of the talents produced.

Building upon this as a foundation, countermeasures to strengthen China's vocational and technical education system should be done in order to solve the problems existing in the current education system. By creating an environment that promotes teaching and learning through competitions, it becomes crucial to improve the students' professional skills and practical abilities. This can improve the quality of talent training and cultivate more high-quality skilled talents to meet the needs of society.

2. The teaching status and problems of the course "Reading of Concrete Structure plan and plan Construction Drawings" in higher vocational colleges

2.1. The course content is extensive and the class hours are short

The course "Reading of Concrete Structure plan and plan Construction Drawings" is usually offered in the first year of higher vocational colleges. However, students lack the necessary professional basic knowledge, and the course covers a wide range of topics. Because of this, it is very difficult for students to fully and accurately comprehend the content of this course in a short period of time [1]. To address this issue, arranging the course content to reasonably fit within a short learning period should be prioritized.

2.2. The content of the course is extensive but lacks practical training

The course on plan method construction drawing reading covers a wide range of topics and has relatively high requirements for fundamental mechanics and related design principles, making it relatively difficult. However, the basic concepts presented in the textbooks are difficult and complex, making it difficult for students to properly understand. Additionally, traditional teaching approaches have very little requirements for practical training. The lack of proper course design and practical activities makes it difficult for students to truly understand the underlying principles, making it more difficult for students to apply those principles to their subsequent construction drawing designs. Therefore, it is important to properly set up the curriculum to effectively strengthen students' understanding and application of basic knowledge.

3. The foundation for the implementation of the practical teaching mode "promoting teaching and learning through competitions"

3.1. National policy advocates vocational skills competition

In recent years, China has put more emphasis on vocational college education, leading to the reiteration of the slogan "general education has college entrance examinations and vocational education has competitions" [2]. It is reported that the "National Higher Vocational Graduate Skills Competition", a national higher vocational graduate skills competition led by the Ministry of Education and co-sponsored with relevant departments, was carried out nationwide. In 2014, the "Decision of the State Council on Accelerating the Development of Modern Vocational Education" [3] stated the urgent need to establish a modern vocational education system and cultivate high-quality talents. This indicates that the expedited reform of vocational colleges and implementation of vocational skills competitions is an essential measure to promote the reform of vocational education.

After more than ten years of development, the "plan method" has been widely recognized as a relatively scientific approach to reading construction drawings. Through the prioritization of curriculum in professional competitions, as advocated by national policies, students will have undergone training after many competitions. Consequently, this will improve the students' ability to use the "plan method" to read construction drawings and improve their competitiveness in the industry.

3.2. Skill competitions are an essential teaching practice at higher vocational colleges

The content of vocational technical competition is based on the students' daily learning content, however the current situation of many higher vocational technical education is not ideal. Firstly, considering the background of the student, the overall quality of graduates from China's higher vocational and technical colleges is generally low. Regardless, most college students are also full of energy, practical, and are eager to showcase their abilities. Schools can capitalize on this and improve the curriculum of the course by incorporating practical elements, integrating competitions into the course, and encouraging students to participate in various vocational skills competitions. In the process, the "plan method" should be applied to the reading of actual construction drawings, so that students' learning enthusiasm and initiative can be effectively harnessed. This approach will not only broaden students' horizons and improve their overall quality, it can also enhance their teamworking ability and competitiveness, which provides favorable conditions for their future employment [4].

Secondly, in terms of the structure of the teaching team, although many higher vocational technical colleges have made adjustments to the curriculum and teaching methods of this major, the desired results have not been achieved, thus there is an urgent need to address this concern. Incorporating competitions into the classroom and reforming the practical teaching method not only allow students to apply their acquired knowledge flexibly in the competitions, but also serves as a means to evaluate the teacher's teaching ability and teaching outcome.

4. The importance of the teaching mode of "promoting teaching and learning through competition"

4.1. Enhancing the integration of "teaching X course from the ideological and political perspective" in colleges and universities

Colleges and universities should incorporate the ideology of "teaching X course from the ideological and political perspective" into their school's development plan, with the fundamental objective of building morality and cultivating people. By doing so, schools can build a comprehensive teaching system which better integrates teaching with competition, in order to enhance students' enthusiasm for learning through competitions, and help them develop good communication skills and professional qualities. By combining "teaching X course from the ideological and political perspective" with competition-based training, colleges and universities can improve their overall teaching quality. It is necessary to strictly follow the structural construction drawings during the project preparation until the quality acceptance of the later construction. However, during competitions, students can use the "plan method" to read drawings, communicate effectively with team members, and promote the improvement of their ideological and moral standards.

4.2. Enhancing teachers' awareness of "teaching X course from the ideological and political perspective"

To improve the effectiveness of "teaching X course from the ideological and political perspective" teaching mode, it is important for teachers to grasp the key points and secondary content of teaching, in order to improve their evaluation methods and corresponding assessments. Performance evaluations and incentives specific to "teaching X course from the ideological and political perspective" are crucial for motivating professional teachers to fulfill their fundamental task of building morality and nurturing students. This approach improves the quality of ideological and political education and prevents ineffective lectures and redundant teaching approaches.

Furthermore, situational teaching can be employed to facilitate collaboration between teachers and experts from various fields, enabling them to analyze construction drawings together, expand their knowledge, deepen their understanding of professional subjects, and enhance their professionalism and

expertise. Teachers are the mainstay of course reconstruction and teaching reform. Therefore, teachers should closely monitor industry and commerce trends and conduct in-depth research in their respective fields [5]. Concurrently, actively participating in various teaching technology competitions, and can further benefit teachers, as they can gain insight into professional challenges during the competition. This will enable teachers to teach the course in a more targeted manner, improve teaching quality, and achieving favorable teaching results.

4.3. Achieving the comprehensive development of students' "learning X course from the ideological and political perspective"

Educational reformation with the ideology of "learning X course from the ideological and political perspective" overcomes traditional monotonous teaching methods, and maximizes students' enthusiasm for learning. The format, content and effectiveness of classroom teaching will significantly impact the quality of education. In order to enhance students' practical skills in architectural and computer drawing, and to break away from traditional teaching modes, colleges and universities can update the course to align with the drawing ability requirements of the professional position. Schools can redesign the training project to simulate real working environments, in order to achieve the teaching objective of "using actual engineering as the background, the teacher as the lead, and the students as the main body" [6].

During class, real engineering design drawings can be used to shift the focus from pure theory or knowledge points to the drawings, incorporating all relevant knowledge into the drawings. Specific knowledge points serve as an important content to guide students in reading actual engineering drawings. For drawing marks and symbols that they do not understand, students can actively search in the textbooks or ask teachers for guidance. The classroom experience is transformed into a working process, which turns the passive learning of students into an active task-oriented activity. To complement this classroom teaching method, a situational teaching component can be introduced. In order to complete an architectural engineering drawing, students can be assigned into groups that will play different roles: the designer, construction party, supervisors, and etc. The designer will first present an overview of the project, while the construction party and supervisor pose questions for the designer to answer. The teacher will be responsible for supervising the entire process while promptly answering students' questions. This practice will allow students to exercise their abilities in all aspects. By combining situational teaching and competition, students' teamwork and communication skills are enhanced, knowledge is applied flexibly, and their professional qualities are improved.

5. The implementation process of "promoting learning and teaching through competitions, and combining competitions and lessons" for course reformation

5.1. Integrating curriculum and competition projects

To integrate curriculum and competition projects effectively, industry experts and teachers from relevant universities can be invited to analyze the competition's content and requirements. This analysis can then be refined through practical work and transformed into a comprehensive teaching plan. This will allow students to fully understand the cutting-edge concepts of the competition and the advanced equipment used. Moreover, it helps cultivate students' abilities in reading structural construction drawings, steel bar lofting, and steel bar engineering acceptance. By enhancing these skills, students can improve their competitiveness in future employment opportunities. Additionally, teachers should actively develop various teaching resources to make the content of the competition more popular. It is also important to integrate the proper standardization requirements of the competition into every course and project.

5.2. Integrating teaching resources and competition resources

To facilitate the integration of teaching resources and competition resources, relevant departments should provide students with more training equipment after the competition to ensure that students can get more practical training. Each competition should reflect the industry's development status. Taking the various competitions as opportunities, integrating the scientific layout of the experimental training base, the competition equipment, teaching and training equipment, and management equipment with the management facilities of the enterprise should be done. Concurrently, by improving the application and management of related equipment, a good practical teaching environment can be cultivated for the students. Moreover, the schools should ensure that there are enough equipment and activities, so as to improve students' practical application skills and ensure the learning outcome of professional skills courses [7].

Furthermore, to support the organization of competitions, the influence of experienced coaches should be leveraged to expand the scope of the knowledge with each knowledge point. All teachers should actively participate in competitions as an integral part of their professional development. By engaging in competitions and educational practices, teachers can enhance their teaching abilities and overall professional qualities.

5.3. Integrating teaching process and competition process

(1) Implemention of subject competitions

In recent years, a shift has been made from traditional classroom teaching to the implementation of subject competitions, which replaced traditional examinations with competitive assessments. The competition method is based on the specific situation of the class (either team competition or individual competition system), and is done to examine whether the students have achieved the teaching objectives of particular stages. By doing so, a more comprehensive evaluation of the students' practical application ability and mastery of knowledge can be obtained. This approach allows for better adjustment of teaching tasks and enhances teachers' teaching quality [8].

(2) Implementation of technical competitions

The colleges and universities can hold a professional technical competition annually to showcase the school's educational achievements. These competitions serve as a platform for colleges and universities to engage in meaningful discussions with enterprises regarding the competition's content and employers' talent requirements. This will allow the school to establish corresponding training objectives, enabling a joint formulation a set of more scientific and reasonable competition standards and rules. For example, the competition can focus on various aspects, such as staking out the steel bar according to the drawing. This allows the cultivation of the students' ability to identify issues in steel bar construction from the structural construction drawings, and through practical application, propose effective solutions.

(3) Implementation of training competitions

On the basis of the outstanding players in college-level competitions and according to the wishes of the students, the competition team can be expanded to establish a training team. This initiative encourages students to actively participate in training and fully immerses them in the competition experience. Concurrently, regular training competitions should be organized, so that students can not only learn professional skills and enrich their own knowledge system, but also conduct multi-faceted inspections. Concentrated training methods can be employed, where a large number of students will become the backbone of the team, cooperate with teachers who will give technical guidance, and promote the collective improvement of all students [9].

5.4. Integrating teaching evaluation and competition evaluation

In teaching, it is crucial to improve the teaching evaluation system based on competition standards. The evaluation system should emphasize on accessing students based on the degree of the students' mastery of knowledge and skills, through the administering of tests with various topics. Furthermore, the emphasis should be on the students' ability to analyze and solve problems according to job requirements and the actual scenarios. It should also focus on the quality of students' practical skills, innovative thinking skills and teamwork spirit, so as to comprehensively improve the students' vocational skills [10].

6. Prospects for the practical teaching mode of "promoting teaching through competitions and promoting learning through competitions"

Currently, various industries are witnessing an increased number of competitions, prompted by China's call for participation. Through competitions, there has been progress in the reformation of the curriculum and teaching method for the course "Concrete Structure Plan Method Construction Drawing Reading". Simultaneously, the overall quality of teachers, as well as the professional skills and practical hands-on capabilities of students have greatly improved. There is a dire need for teaching reform in modern higher vocational schools, and although results have been achieved in the process of implementing this change, there is still room for improvement. It is essential to ensure the smooth continuation of this reformation to achieve the desired objectives.

Disclosure statement

The author declares no conflict of interest.

References

[1] Su R, Zhu H, Liu X, et al., 2016, The Course Construction and Practice of "Recognition and Reading of Concrete Structure Plan and Plan Construction Drawings". Journal of Higher Education, 37(13): 134–137.

[2] Li Y, 2010, General Education has College Entrance Examination, Vocational Education has Competition. Mold Industry, 36(09): 73.

[3] State Council, 2014, The Decision of the State Council on Accelerating the Development of Modern Vocational Education, viewed June 2, 2023 https://www.gov.cn/zhengce/content/2014-06/22/content_8901.htm

[4] He P, Yang Y, Liu L, 2015, Talking about the Practical Teaching Mode of Combining Teaching Work and Student Association Activities. Higher Architectural Education, 24(05): 151–153.

[5] Cheng G, 2018, Three Focuses on Promoting the Teaching Reform of "Teaching X Course from the Ideological and Political Perspective". Ideological Theory Education Guide, 2018(09): 67–70.

[6] Chen Y, Liu J, Tang X, et al., 2015, Promoting Learning through Competition, Promoting Training through Competition, and Promoting Teaching Through Competition-Exploration and Practice of Teaching Mode Combining Competition and Teaching for Engineering College Students. China Management Information, 18(13): 246–248.

[7] Cai Z, 2018, Analysis on the Reform of the Teaching Mode of "Promoting Learning through Competitions, Teaching through Competitions, and Combining Competitions and Classes" for Marketing Majors. Contemporary Educational Practice and Teaching Research, 2018(10): 155–156.

[8] Liu N, 2019, Investigation and Research on the Integration of Subject Competition and Professional

Teaching. Education Modernization, 6(93): 211–212.

[9] Xu Y, Zhou H, 2019, Research on Skills Competition Training in Vocational Colleges. Big Vision, 2019(04): 50–54.

[10] Ye L, Liu Y, 2014, Research on the Establishment and Implementation Strategy of "Dualized" Teaching Evaluation Mechanism Supported by Competition Projects. Times Education, 2014(20): 105.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Analysis on the Characteristics and Laws of Tunnel Hydraulic Inrush in Karst Area

Xingxing Wang*, Senyang Wu, Donglin Dai

China Merchants Chongqing Highway Engineering Testing Center Co., Ltd., Chongqing 400067, China

***Corresponding author:** Xingxing Wang, Wxx274@126.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: As highways are extended to deep mountains, high altitudes, and special geological conditions, tunnel construction becomes more and more challenging, especially the construction of tunnels in karst areas. Due to the particularity of the regional geological structure, karst is well developed in the southwest of our country, especially at areas where the problem of tunnel water inrush in karst areas is more prominent. To further ensure the safe construction and operation of tunnels, the characteristics of tunnels in karst areas is analyzed in this article.

Keywords: Karst area; Tunnel; Water inrush; Mechanics

Online publication: July 28, 2023

1. Introduction

According to research, there are four conditions that affect karstification: the solubility of rocks, the permeability of rocks, the fluidity of water, and the corrosivity of water. Karstification will occur if these four conditions are met.

With the extension of highway construction to deep mountains, high altitudes, and special geological conditions, tunnel construction is facing more and more technical challenges, especially the construction of tunnels in karst areas.

Due to the particularity of the regional geological structure, karst is well-developed in the southwest of our country, especially at areas where the problem of tunnel water inrush in karst areas is more prominent [1]. To further ensure the safe construction and operation of tunnels, the characteristics of tunnels in karst areas is analyzed in this article.

2. Main influencing factors of karst development

2.1. Lithology

Lithology is the material basis and the main factor controlling the development of karst. Different types of karst formations have different degrees of karstification. For example, the mud in the argillaceous limestone aquifer leads to the formation of thin-layer structures and fine cracks, which become seepage channels for the dispersion of groundwater in the mountain, so the karst development is scattered. Generally, a network of dissolution fractures is formed rather than a large cave system. Carbonic acid causes a “double erosion” effect, which can dissolve nearly 20% of the calcite of rock formations in volume [2].

It has been found that the diagenetic minerals of different soluble rock groups, the composition of trace minerals, and the organizational structure have an important impact on the four conditions of the aquifer: solubility, water permeability, self-erosion, and water movement. Lithology determines the

mechanism and display strength of karst medium based on these four basic conditions.

2.2. Geological structure

Geological structure plays a leading role in the development of karst, it not only controls the direction of karst development, but also affects the scale of karst development.

Tensile fault zones are affected by tensile stress, and the width of the fracture zone is generally not large, but the degree of tension cracks is large, and the fault surface is rough and uneven. It is a favorable channel for karst water, so the degree of karstification is usually the strongest [3] .

2.3. Topography

The surface karst form is the surface trace of the underground river system, and depressions, funnels, and sinkholes are all input points of the underground river system. Large-scale input points such as depressions and underground extensions of underground river inlets are channels for high-level tributaries of underground rivers.

The development of karst is largely affected by surface water and seepage conditions, and these two are often affected by landform conditions, such as ground slope, cutting density and depth, water system distribution, etc., and the process of development is also different.

3. Characteristics of disasters and analysis of tunnel water inrush

The factors affecting karst water inrush are caused by geological factors and engineering factors, and it occurs when there are contradictions between to two factors. The reason of occurrence and influencing factors of water inrush determine the type of water inrush. In terms of geological factors, the karst water-bearing medium usually has great heterogeneity and diversity, and the water distribution is extremely uneven, where laminar flow and turbulent flow coexist, small fissures constitute the main water storage space and large water inrush channel. In terms of engineering factors, rock mass excavation and unloading, blasting disturbance and grouting failure, etc. are the main contributors to the hysteresis and uncertainty of water inrush [4].

3.1. Conditions for water inrush

Underground construction will inevitably destroy the concealed water-bearing structure, causing the aqueduct to be connected or quasi-connected with the excavation surface, and further disturbance will cause the groundwater or other water bodies that are hydraulically connected to the aqueduct (surface water, underground rivers and molten pools, etc.) to suddenly pour into the excavated area, causing water inrush. Therefore, from the perspective of system theory, certain conditions must be met for the occurrence of karst water inrush, namely the energy storage of water-bearing structures, karst hydrodynamic performance and energy release, and the stability of surrounding rocks.

3.2. Factors affecting of water inrush

In essence, karst water inrush is a phenomenon of dynamic instability caused by external interference of groundwater migration network or storage conditions. There many factors that influences the occurrence of water inrush, but it can be generalized into geological factors and engineering factors [5].

(i) Geological factors

In terms pf engineering factors, construction induces water inrush, but hydrogeological conditions are the main influencing factors of water inrush, and the hydrogeological conditions are controlled by the topographical conditions, stratum lithology, geological structure and karst hydrodynamic zoning conditions of the construction area, etc.

(ii) Engineering factors

The engineering factors affecting karst water inrush are mainly excavation and the vibration caused by blasting. During the construction of underground projects, the construction methods and techniques may induce karst water outburst, and even poor grouting may cause delayed water inrush disasters. However, according to the statistics, most of the water inrush occurred after construction blasting and excavation. Therefore, it is clear that excavation and blasting are the most important influencing factors among engineering factors.

3.3. Types of water inrush

There are many types of karst water inrush, but in terms of the specific attributes of the inrush prevention structure, water inrush can be divided into two types: geological defect type and non-geological defect type water inrush.

Water inrush can be divided into four grades according to the amount of water, as shown **Table 1**.

Table 1. Types of water inrush divided by water inrush volume

Level code	Water volume, Q (m^3/h)	Description
Grade A	>10000	Occurs instantly with a water pressure is greater than 0.5 MPa and lasts for a last time
Grade B	1000–10000	Transitional, with water pressure less than 0.5 MPa.
Grade C	100–1000	The water pressure is small, and the flow depends on the dynamic water pressure, which does not affect the construction.
Class D	10–100	The groundwater flows slowly, and the drainage requirements can be met during construction along the slope.

3.4. Water inrush method

There are a few ways in which water inrush can occur: instantaneous water and mud inrush, stable water inrush, and seasonal inrush. Instantaneous water and mud inrush: When the karst pipeline is exposed during the construction of a tunnel, groundwater or underground mud-rock will spurt from the pipeline mouth with huge pressure (1–3 MPa) in an instant, and its flow rate can reach thousands of cubic meters or even more than 10,000 cubic meters per hour. Stable water inrush: there is no significant change in the amount of water before and after construction even when the karst pipeline is exposed and the groundwater flows under the action of water pressure. Seasonal water inrush and gushing: When dry caves or water-filled caves with relatively large catchment areas are close to the tunnel, , the karst pipeline will be filled with water rapidly after continuous rainfall or a heavy rain, water inrush will occur, causing underground debris to flow along the pipeline [6].

3.5. Impact of water inrush

The impact of karst water inrush can be divided into three categories: serious loss, medium loss and slight loss. The most serious water inrush is categorized as grade A, where underground debris flow occurs, and the tunnel is forced to shut down for more than 3 months, causing huge economic losses, casualties, and other major accidents; the moderate inrush and mild inrush are categorized as grade B and C, respectively, in which the tunnel is forced to shut down for 1 month when during seasonal water inrush, causing a certain amount of property damage; the amount of water gushing with minor losses is grade C, D, and the tunnel is forced to shut down for 10 days [7].

3.6. Protrusion prevention structure

In terms of water inrush damage, karst water inrush can be divided into three types: geological- defect water inrush, non-geological defect water inrush, and combined water inrush. This form of categorization is closely related to the outburst prevention structure and water inrush channel, as shown in **Table 2**.

Table 2. Types of water inrush by failure mode

Water inrush type	Inrush prevention structure	Water inrush channel
Non-geological defect type	Complete surrounding rock (outburst prevention layer)	In the early stage, it is a network of fractures, and in the later stage, it is the rupture of the aquitard
Geological defect type	Filling medium	Cracks, faults, dissolved cavities and karst pipes, etc.
Modular	End core surrounding rock + filling medium	Different combinations of the above two water inrush channels.

For non-geological defect water inrush, that is, when there is no obvious geological defect between the tunnel surface and the nearby water-conducting structure, the water rushes in from the fault zone; for combined water inrush, if the geological defect that is hydraulically connected to the water-conducting structure does not intersect the tunnel, tunnel water inrush will not happen unless both of the filling medium and inrush prevention structure are unstable.

4. Analysis of basic mechanical characteristics of water inrush in tunnel

Water inrush in karst areas is essentially a dynamic damage, which is due to the drastic changes in the mechanical balance of the karst water-bearing medium, hydrodynamic system, and surrounding rock due to underground excavation, resulting in the instantaneous release of energy stored in the groundwater body. and the water gushes out of the ground at a high speed In terms of water-rock interaction mechanism, there are two processes to a karst water inrush: potential storage and instability. Potential storage is a gradual process, and it eventually turn into instability, which is an instant process, after some time.

4.1. Potential storage process of water inrush

Karst water inrush is a dynamic damage in which long-term water-rock interaction induces rock mass rupture, instability, and water inrush stimulated by external forces during a construction. The effect of water and water pressure on the softening, dissolution, and stress of rock mass takes long time.

(i) The softening and dissolution effect of karst water on fractured rock mass

Under karst water dissolution, the strength of rock under saturated water state and the strength of dry rock can be deduced according to the following relationship

$$\sigma_w = \eta K_w \sigma_0 \, (K_w > 1)$$

In the formula, η is the rock strength reduction coefficient within the safe thickness range, and its value is related to the degree of rock dissolution and the rock humidity of the water inrush surface; K_w is the rock softening coefficient, and its value mainly depends on the lithology of the rock.

(ii) Effect of karst water pressure on the stress of fractured rock mass

The mechanical effect of karst water pressure on fractured rock mass is mainly reflected in its effective stress and softening effect. Since these two effects are related, the comprehensive mechanical effect can be expressed by the following formula:

$$\Delta t = \sigma(\tan\varphi - \tan\varphi_w) + P_w\tan\varphi_w + CC_w$$

In the equation above, Δt is the reduction value of the shear strength of the fractured rock mass caused by karst groundwater; P_w is the karst water pressure; C and φ are the connection force and friction angle of the fractured rock mass before water immersion; C_w and φ_w are connection force and friction angle of post-fractured rock mass after water immersion. For the karst confined water in the tunnel floor, the influence of karst water pressure P_w on the strength of fractured rock is more significant due to the vertical pressure relief of the floor strata after excavation [8].

4.2. Instability characteristics of water inrush

Based on the diversity of the torrent-proof rock mass structure, karst water inrush has multiple failure modes. For water-bearing structures with obvious geological defects, such as fractured rock masses, faults, and filled karst pipelines, the water inrush channels are regular, and the instability and failure modes are relatively fixed. For fractured rock mass, there is hydraulic fracturing cause by the water inrush.

The erosion and expansion of the water flow on the water inrush channel is used in the water inrush of underground engineering. There is always a fixed initial channel at the moment of failure and instability for any type of water inrush, but the shape and boundary of the water inrush channel are different. However, with the further development of water inrush, the walls along the channel will be continuously destroyed and peeled off, thus increasing the volume of the water inrush channel. Microcracks or other geological defects that cause cracks can be described by the following model.

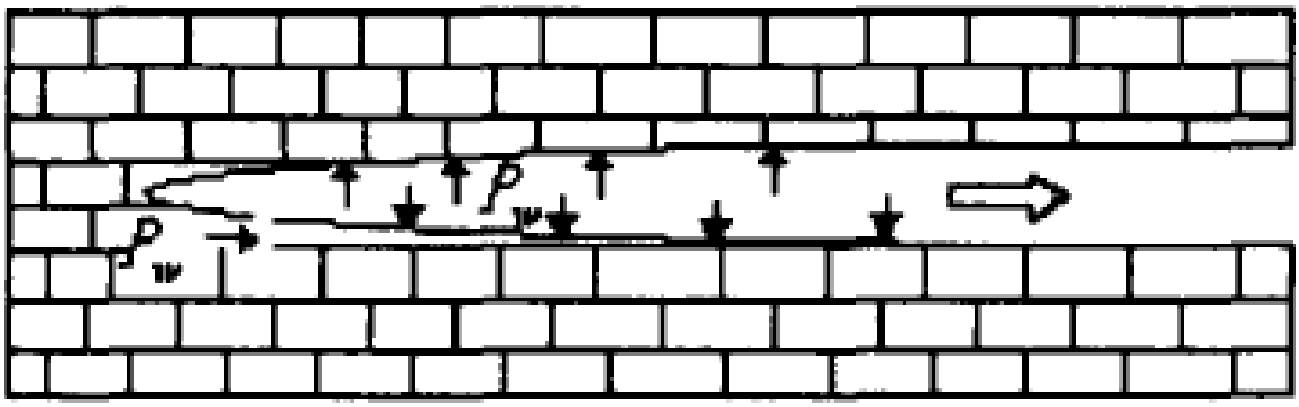


Figure 1. Calculation model of diameter expansion by water flow erosion

4.3. Analysis of source of water inrush

The driving force of water inrush can be divided into hydrostatic pressure water inrush and dynamic water inrush. Hydrostatic pressure water inrush occurs under the action of a large static storage water body, and as the inrush prevention of the structure gradually weakens, the water body will slowly become unstable and finally gush out. Dynamic inrush is where the body of water is impacted by an external force, which stimulates high water pressure, and instantly forms a water inrush channel. **Table 3** shows the difference between dynamic water inrush and hydrostatic pressure water inrush.

Table 3. Classification of water inrush sources

Type of water inrush	Hydrostatic pressure inrush	Power water inrush
Source of water	Aquifers, surface water, old empty water, etc.	Delaminated water
Aisle	Water-conducting fissure zones, faults, karst pipelines, etc.	Dynamic breakthrough zone
Precursory features	Increased water seepage on the wall surface, sediment discharge, etc.	No warning signs
Water inrush	Irregular, controlled by water pressure and channel etc.	The instantaneous water inrush is large and the decay is fast
Water inrush process	Similar to a water bottle with a loose cork turned upside down and water flowing out	Can be described as pressing against a hot water bag, causing the water burst out

Apparently, static water inrush is more common, and dynamic water inrush requires a certain power source.

The formation of water channels is mainly due to the action of dynamic damage and excess hydrostatic pressure, while the hydrostatic pressure inrush is mainly due to the hydrostatic pressure of the original aqueduct.

5. Conclusion

Through the analysis of the mechanical characteristics and laws of tunnel water inrush in karst areas, several conclusions can be drawn.

(i) Through the analysis of the characteristics and laws of tunnel water inrush, it is possible to preliminarily determine the high-incidence areas of and areas prone to tunnel water inrush.

(ii) In the process of tunnel construction in karst areas, various means such as TSP (tunnel seismic prediction), geological radar, transient electromagnetic, direct current, and infrared water detection can be used to carry out advanced geological prediction.

(iii) Through the analysis of tunnel hydraulic inrush characteristics, corresponding design parameter adjustments can be adopted to ensure construction and operation safety.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Feng X, Zhou X, Hu Y, 2022, Research Progress on Tunnel Water Inrush Mechanism in Karst Areas. Journal of Wuhan Engineering University, 44(03): 250–259 + 354.

[2] Li Y, Yin H, Li B, 2020, Comparative Study on Lining Types of Anti-Water Pressure of Tunnels in Karst Area. Highway, 66(06): 411–415.

[3] Wang J, Wang L, Ma J, et al., 2020, Analysis of Treatment Measures for Highway Tunnels Crossing Large Karst Caves in Karst Areas. Journal of Underground Space and Engineering, 16(S2): 964–970 + 998.

[4] Zhang K, Chen S, Huo X, et al., 2019, Extension Evaluation Model and Application of Tunnel Water Gushing Risk in Karst Area. Modern Tunnel Technology, 56(04): 89–96.

[5] Liu Z, Zheng J, 2018, Treatment Technology of Existing Structures Under the Shallow Buried Section of Tunnel in Karst Area. Journal of Railway Engineering, 35(02): 51–55 + 78.

[6] Zou Y, He C, He C, et al., 2014, Analysis of Leakage Disease Characteristics and Cause Mechanism of Seasonal Water-Rich Operating Tunnels in Chongqing Karst Area. Modern Tunnel Technology, 51(04): 18–27 + 45.

[7] Wu K, Ma M, Li S, 2011, Comprehensive Geophysical Prospecting Research on Tunnels in High-Risk Karst Areas. Journal of Underground Space and Engineering, 7(01): 106–111.

[8] Li L, Li S, Zhang Q, et al., 2010, Research on Mechanics Mechanism of Fissure Water Outburst in Tunnels in Karst Area. Rock and Soil Mechanics, 31(02): 523–528.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Earthwork and the Strategies of Concrete Construction Technology Application in Building Construction

Lisheng Feng*

Huaibei Key Project Construction Management Office, Huaibei 235000, Anhui Province, China

***Corresponding author:** Lisheng Feng, 937715122@qq.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The pouring of mass concrete and earthwork account for a large proportion in building construction, which can play a decisive role in the quality of the building. Therefore, it is necessary to understand the technology of earthwork and concrete engineering in the process of building construction and propose reasonable application strategies.

Keywords: Housing construction; Earthwork; Concrete engineering; Construction technology

Online publication: July 28, 2023

1. Introduction

Earthwork and concrete engineering can have certain impact on the quality and efficiency of housing construction and to a certain extent determine the overall safety of the building. Therefore, it is necessary to conduct in-depth discussions on advanced construction technologies and make reasonable adjustments according to the conditions of construction, with focus on earthwork and concrete engineering of housing construction. In this way, construction technologies can be utilized and the quality, efficiency, and safety of housing construction can be ensured. Therefore, it is of great significance to analyze the application strategy of earthwork and concrete engineering in housing construction.

2. Earthworks of housing buildings

2.1. Preparatory work for earthworks

2.1.1. Measurement and setting out

Firstly, the construction site was surveyed, and the position of each control point in the earthwork is determined. Next, the traverse point and leveling point are remeasured, each point in the design plan has to be consistent with the ones on site. If they are consistent, the next step can be carried out; if there are any inconsistencies, reasonable adjustments should be made accordingly to ensure that the subsequent steps can be carried out smoothly [1].

2.1.2. Construction site treatment

The construction site should be cleaned up before entering the construction stage. The thickness of the cleaning should exceed 0.3 m. No garbage, sundries or other factors that may affect the operation of mechanical equipment should be left in the site. Besides, the area that is cleaned should be larger than the area needed for the construction. The cleaning thickness should be further increased especially in poor

geological environments, and a more detailed treatment of roots, sod, and humus should be carried out to avoid the subsequent construction being affected.

2.1.3. Preparation of equipment

There are many types of mechanical equipment involved in earthworks, including excavators, bulldozers, compactors, etc. In order to ensure a smooth construction, a comprehensive inspection of the equipment's performance should be carried out, and any faults should be eliminated. Besides, it is important to make sure that the equipment operates normally, and performance debugging and moderate maintenance should be performed. With the aforementioned steps done, the equipment can then be used in the construction.

2.2. Excavation

The excavation process in housing construction is mainly done with a machine. It is necessary to determine the specific excavation volume according to the design plan and control the excavation area based on relevant requirements. The excavation should be done layer by layer to avoid landslides on the side slope of the foundation pit. When the excavation depth reaches about 20 cm from the designed depth, the operation should be suspended, and control piles should be installed at the corresponding positions, or manual excavation can be performed, so as to improve the accuracy of excavation and prevent over-excavation [2].

2.3. Backfill construction

Bulldozers should be used for backfilling to improve construction efficiency, and supporting compaction equipment should be used simultaneously to carry out compaction treatment in a timely manner to ensure that the backfill position is stable. Because the working space is relatively limited, it is not advisable to use large-scale machinery, so frog-type tamping machines is generally used, and attention should be paid to controlling the thickness of the filling. Generally, the thickness of filling should not exceed 25 cm to avoid affecting the compaction effect.

2.4. Compaction

Common compaction methods include rolling and tamping. In the rolling method, the soil is compacted using a roller. The area of pressure of a sheep foot roller is relatively large, which is suitable for cohesive soil. A flat roller, also known as smooth roller, is an automated roller that is suitable for large-scale rolling. The goal of compaction is to increase the compactness of the soil through the force generated by the free fall of a rammer. This has been established for a long time, and the rams used include wooden rams, stone rams, pneumatic rams, frog rams, etc. It can be applied to cohesive soils and collapsible loess, which is conducive to the improvement of inclined holes in the soil.

2.5. Wellpoint

2.5.1. Light wellpoint

Several small-diameter well point pipes are embedded on the aquifer around the foundation pit, where its upper part is connected to the main pipe, and the main pipe is connected with the pump, so that the groundwater can flow out of the well point pipe and the groundwater level can be lowered to the bottom of the pit. This method is mainly suitable for the soil layers with a permeability coefficient of $K = 0.1–50$ m/d. The depth of precipitation of single-level light scenic spots can reach 3–6 m, and the precipitation depth of multi-level light scenic spots can reach 6–12 m [3].

2.5.2. Self-jetting wellpoint

If the foundation pit is relatively deep, the self-jetting method of wellpoints should be adopted, and its precipitation depth can reach 8–20 m. The equipment is composed of jet well pipe, water inlet pipe, drain pipe, and high-pressure water pump. The jet well pipe consists of two parts, the inner and outer parts. When the annular space between the parts is sprayed with water by the nozzle, the groundwater can be sucked into the pipe and then pressed out of the ground.

2.5.3. Electroosmotic wellpoint

Electroosmotic wellpoints are mainly suitable for soil layers with a permeability coefficient of below 0.1 m/d. It is difficult for ordinary well points to effectively reduce the groundwater level in this type of soil layer. Therefore, electroosmotic wellpoints are particularly suitable for the drainage of silt layers. In the process of electroosmotic wellpoint, the well point pipe is the negative pole, and the steel pipe or steel bar driven in is the positive pole after it is connected to a direct current supply. The soil particles move from the negative electrode to the positive electrode, and the water moves from the positive electrode to the negative electrode and is discharged. The movement of soil particles is an electrophoretic phenomenon.

2.5.4. Tube well

A tube well is set every 20–50 m along the periphery of the foundation pit, and each tube well corresponds to a water pump, which pumps water outward to lower the groundwater level. This method is mainly suitable for soil layers with large amounts of groundwater and a permeability coefficient of K = 20–200 m/d.

2.5.5. Deep well pumps

If the required precipitation depth exceeds 15 m, and the use of ordinary submersible pumps or centrifugal pumps are insufficient, special deep well pumps can be used.

2.5.6. Soft soil foundation treatment

If the construction site has a soft soil foundation, because the stability and bearing capacity of this part are weak, it is necessary to perform suitable soil treatment method in order to avoid uneven settlement. Common treatments include replacement bedding and chemical reinforcement. Replacement cushions should be applied when the soft soil layer is thin or the groundwater level is low. Chemical reinforcement treatment involves using chemicals to react with the soft soil foundation improve the stability of the foundation. In some cases, loading compaction technology can also be used, that is, to perform compression treatment on soft soil foundations, and to improve the consolidation of soft soil foundations by strengthening overload settlement, so as to improve the stability of the soil.

3. Concrete construction in housing building

3.1. Controlling the quality of concrete raw materials

Cement is the most important raw material in concrete. It is mixed with water to form cement slurry, which can not only wrap the surface of the aggregate, but also fill the gaps between the aggregate and lubricate it before it hardens. Cement also binds the aggregate together during the hardening process. The cement used should be purchased from reliable manufacturers, and low-heat types should be selected. It is also necessary to verify the details and certifications of the cement and check the parameters of the cement material to confirm that it can meet the actual construction needs. High-quality medium-coarse sand and coarse aggregate should be matched with suitable crushed stone. Besides the mud content of fine aggregate should be controlled. Then, a suitable shape and particle size and the strength of coarse aggregate is selected.

Adding an appropriate amount of admixtures can improve the concrete and save water and materials to some extent. Common admixtures include water-reducing agents and air-entraining agents, which can improve the polymerizability and water retention of concrete. The temperature of hydration should be controlled to avoid severe shrinkage and cracks in concrete caused by changes in external temperature [4].

3.2. Controlling the ratio of raw ingredients in the mixture

The ratio of raw ingredients in a mixture can directly affect the quality of concrete, so on the basis of using high quality raw materials, the ratio of the raw materials used should be reasonably controlled based on the needs of the project. The proportion of each raw material is first calculated, and the materials are added according to a specific sequence. The materials are then mixed for a specific period of time. It is important to supervise the entire process of making the mixture. Afterwards, the outbound concrete should be inspected in batches to ensure that all the concrete meets the relevant requirements [5].

3.3. Concrete transportation

To ensure that the concrete used is as "freshly made" as possible, the concrete should be transported to the construction site as soon as possible after quality inspection. Besides, it is also important to ensure the continuity of concrete supply during the pouring process to ensure a smooth construction process. Moreover, the transportation route should be reasonably planned according to various conditions, and the transportation distance and transportation time should be shortened as much as possible to control the slump of the concrete. It is also necessary to use dump trucks as transportation vehicles to make loading and unloading easier.

3.4. Concrete pouring

In terms of concrete pouring, technicians should check the post-pouring belt before pouring to confirm that it complies with relevant regulations. The concrete formwork should be treated to ensure that there is no oil or foreign matter on the surface, so that defects such as pockmarks can be prevented [6].

It is important to pay attention to several aspects during the pouring process. First, the pouring speed should be controlled to avoid the formation of cold joints [7]. Second, the concrete pouring temperature should be controlled to avoid cracks caused by excessive temperature stress. Usually, the lower the pouring temperature, the smaller the temperature difference between the inside and outside of the concrete body during hardening, and the smaller the temperature stress, the less likely cracks will appear. Therefore, generally, the pouring should be performed when the ambient temperature is below 35°C, and the duration of the pouring should be reasonably controlled to improve the pouring efficiency. Third, when performing single-layer pouring, the pouring height should be below 2 m, followed by the pouring of vertical structure parts, in which the height should not exceed 3 m. When pouring beams with integrated columns, walls, and slabs, the beams and slabs should be poured at the same time after 1.5 hours after the pouring of vertical structures is completed, and care should be taken to protect the steel skeleton to avoid its displacement during the pouring process [8]. Fourth, after the pouring is completed, vibration should be carried out remove air bubbles. It is important to check the compactness of the concrete during the process of vibration. Besides, the vibrating rod should not hit the steel bar to prevent the steel bar from shifting. In addition, the principle of fast insertion and slow removal should be followed. The vibration time should be set according to the condition of the concrete surface. The process of vibration is considered complete when there is no slurry, air bubbles, or obvious subsidence on the concrete surface to avoid local voids or segregation [9].

3.5. Concrete maintenance

After the concrete is poured at room temperature, continuous watering and curing should be carried out

within 8 hours to ensure that the concrete is kept in a wet state to improve its molding effect. After the formwork is removed, the concrete should be wrapped with plastic sheeting and water retention measures should be applied [10]. The cast-in-place reinforced concrete floor should be watered appropriately. Under normal circumstances, the concrete should be cured for at least 14 days to ensure that it is properly compacted with a smooth surface.

4. Conclusion

There are high requirements for both earthworks and concrete for housing projects in terms of quality, heavy workload, and long construction period, so they should be highly valued, and the construction conditions should be considered in these two processes. Each construction link should be carried out properly to ensure the construction quality, improve the overall quality of housing construction, and drive the development of the construction industry.

Disclosure statement

The author declares no conflict of interest.

References

[1] Xiong C, Zhao J, Ma T, et al., 2022, Application of Construction Technology for Building Earthwork and Concrete Engineering. Brick and Tile, 2022(10): 164–166.

[2] Zhao Y, Mou T, Zou Q, et al., 2023, Concrete Jacking and Grouting Technology in Long-Span Concrete-Filled Steel Tube Arch Bridge. Highway and Transportation Science and Technology, 40(3): 115–122.

[3] Zhang L, Zhao Y, Wang H, et al., 2022, Construction Technology of Large Steps with Gradient Slope and Curved Surface. Building Construction, 44(10): 2368–2371.

[4] Han J, 2022, Discussion on the Construction Technology of Key Links in the Canal Reconstruction Project of Baojixia Irrigation District. Groundwater, 44(3): 296–297.

[5] Li Q, 2022, Research on Construction Technology of Foundation and Pile Foundation of Construction Engineering. Sichuan Building Materials, 48(6):82–83 + 87.

[6] Fu D, 2022, Construction Technology of Underground Diaphragm Wall and Guide Wall in Subway Station Engineering. Construction Machinery and Maintenance, 2022(1): 178–179.

[7] Zheng J, 2022, Research on the Reconstruction and Reconstruction of Urban Water System ——Taking Huizhou Fengmen'ao Water System Project as an Example. Shanxi Water Resources, 2022(7): 38–41.

[8] Zhou S, 2022, Open Excavation Technology of High Roller Compacted Concrete Double Curvature Arch Dam. Pearl River Water Transport, 2022(8): 101–103.

[9] Liu J, 2022, Discussion on Design of Reinforced Concrete Ring Internal Support in Soft Soil Deep Foundation Pit Support Engineering. Engineering Construction and Design, 2022(16):7–10.

[10] Han L, 2022, Discussion on Construction Management of Deep Foundation Pit Support in Construction Engineering. Engineering Technology Research, 7(24): 119–121.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Design and Operation of Municipal Rain and Sewage United Pumping Station

Ting Ting Liu*

China Merchants Chongqing Communications Technology Research & Design Institute Co., LTD., Chongqing 400067, China

***Corresponding author:** Ting Ting Liu, lting1017@163.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: In the process of designing a municipal rainwater and sewage pumping station, it is necessary to accurately grasp the design points, reasonably determine the scale of the rainwater and sewage pumping station, scientifically select the location and layout, and select materials reasonably. After completing the process design of the municipal rainwater and sewage pumping station and putting it into operation, in order to ensure the normal and stable operation of the pumping station, it is necessary to focus on strengthening the operation and management of diving equipment, cleaning equipment, and electromechanical equipment. The author analyzes the key points and specific design path of the process design of municipal rainwater and sewage pumping stations, and puts forward effective strategies for operation management, hoping to contribute to the scientific design and stable operation of municipal rainwater and sewage pumping stations.

Keywords: Municipal administration; Rainwater and sewage united pumping stations; Design path; Operation management

Online publication: July 28, 2023

1. Introduction

In view of rapid urbanization and industrialization, people have been paying more and more attention to water conservation and reuse. Relevant government departments in our country have also increased their investment in water environment governance. The construction of municipal rainwater and sewage pumping stations plays a very important role in the rational allocation of urban water resources, water supply and drainage, and water transfer and supply. To maximize the value of municipal rainwater and sewage pumping stations, it is necessary to do a good job in designing and strengthening the operation and management of pumping stations.

2. Key points of process design for municipal rainwater and sewage pumping station

(1) Determining the scale of the rainwater and sewage pumping stations

When designing a rainwater and sewage pumping station, it is necessary to conduct an in-depth investigation of the upstream and downstream of the pumping station and collect data related to rainwater and sewage pipe network to determine the pipe diameter and elevation of the pipe network. The flow rate and head of the pumping station can then be determined. At the same time, the discharge flow of rainwater and sewage in the service area of the pumping station is also calculated. The future growth of sewage discharge is predicted according to the development of the area covered by the pumping stations and the overall planning of the city. An appropriate return period is selected according to the location of the pumping station, to calculate the storm rainfall in the service area. The scale of the

rainwater and sewage pumping station the can then be determined based on the prediction of the sewage discharge and the rainstorm within the service range of the pumping station.

(2) Scientific site selection and layout

The municipal rainwater and sewage pumping station is an important infrastructure in the city, and the location of the pumping station is very critical. When selecting the location of the pumping station, it is necessary to conduct a comprehensive analysis of the existing urban municipal drainage network layout, buried depth, and planning of municipal land resources. In addition, it is also necessary to comprehensively consider the environmental benefits the pumping station can bring. When selecting the location and designing the layout of the pumping station, it is important to not only meet the needs of the urban infrastructure, but also to minimize the adverse impact on the urban environment and residents. Besides, it is also necessary to ensure that the layout of the pumping station is conducive to future operation management and maintenance.

(3) Reasonable choice of materials

The quality of sewage water is poor and somewhat corrosive. Therefore, when designing municipal rainwater and sewage pumping stations, it is necessary to choose high-quality, strong corrosion-resistant materials. Moreover, during the construction of the pumping station, the quality and corrosion resistance of the materials must be strictly tested to ensure that the selected materials meet the requirements of the pumping station.

3. The process of designing a municipal rainwater and sewage pumping station

(1) Determining the type of pumping station

There are some differences in terms of the sewage characteristics of the supporting pipe network, hydrological conditions, and operation management requirements for different types of pump stations. According to relevant surveys and studies, there are two main types of sewage pumping stations, one is dry pumping station and the other is wet pumping station. In terms of structure, a wet pumping station is relatively simpler; in terms of investment, a wet pumping station not only has strong corrosion resistance, but also relatively low investment costs, and in some comparative, and it can also operate stably in harsh environments. Because of the many advantages of wet pumping stations, it is becoming increasingly popular. On the other hand, dry pumping stations are easy to repair and maintain, and it is highly adaptable. When designing a municipal rainwater and sewage pumping station, it is necessary to choose the most suitable pumping station form according to the relevant needs.

(2) Ventilation design of municipal rain and sewage pumping stations

The pumping station and the grille are prone to pollution, thus causing odors. Therefore, when designing the pumping station, it is necessary to pay attention to the odor control of pumping stations. Proper ventilation can prevent odors forming in the pumping stations, so as to ensure the service life and performance of the equipment while preventing the odor from affecting the management personnel and the surrounding environment. With the continuous development of society, people are paying more and more attention to energy conservation. Therefore, it is important to utilize natural ventilation, and plants that absorb odors can also be planted for better deodorization.

(3) Grid design of municipal rainwater and sewage pumping station

Judging from the actual operation of municipal rainwater and sewage pumping stations, there are still some deficiencies in the grid design, which are listed in **Table 1**.

Table 1. Deficiencies in the grille design of municipal rainwater and sewage pumping stations

Design problem	Main hazard
(1) No lifting hoist	Affects future development and maintenance
(2) In order to reduce cost, the equipment between the grille and the water inlet gate are directly exposed to the environment	The equipment is exposed to wind and rain and shine for a long time, which makes it prone to corrosion and odor.
(3) No automatic detection and alarm equipment	Harmful gases cannot be detected.
(4) The rotary grille decontamination machine can only salvage hemp rope, cloth strips, etc.	Large objects like wooden blocks cannot be salvaged and need to be removed manually, which increases the workload of the operation and management personnel.

For this reason, when designing the grille of a municipal rainwater sewage pumping station, it is necessary to select the grille strictly according to the requirements and standards of the pumping station for sewage treatment. The types of grilles mainly include coarse grille and fine grille. Generally speaking, sewage treatment plants are designed with coarse grilles, and reasonable adjustments will be made according to the water level of the area where they are located. For this reason, when designing the grille, it is necessary to install a liquid level gauge near the grille to measure the water level in real time. Once the water level difference exceeds 0.2 m, the grille will be automatically activated for slag discharge [1].

(4) Sump design for combined pumping station of municipal rainwater and sewage

The main function of the sump in the rainwater and sewage pumping station is to adjust the water inflow. Through the reasonable design of the sump, the normal and stable operation of the submersible pump unit can be ensured. Therefore, the design of the sump is very important [2]. If the capacity of the sump is too large, it will lead to serious siltation in the sump, which will cost a lot to resolve the issue. However, if the capacity of the sump is too small, it would be difficult to meet the demand for water regulation. Therefore, it is important to design a sump with a suitable capacity. The final capacity of the sump should also be able to adapt to changing water volumes. The capacity of the sump should be designed according to the actual flow of the water inlet pipe, the pumping capacity of the water pump, the number of starts and stops, and whether the capacity of the sump can be adjusted by the water inlet pipe. The capacity of the sump should be minimized to save construction and operation costs and reduce the deposition and corrosion of debris in the sump. Based on the equation of a self-controlled pumping station: $V_{min} = TminQ4$, the minimum volume is directly proportional to the minimum work cycle of the pump. The water pumps in the pumping station are operated according to a certain order, and the order of the water pump operations corresponds to the capacity adjustment of the water pumps. To ensure that the capacity of the selected sump conforms to the minimum capacity, it is also necessary to comprehensively analyze the plane layout of the pumping station and the characteristics of the upper space structure.

In addition, several points need to be paid attention to when designing the sump.

(i) The type of water pump should be reasonably selected to ensure that it not only has good energy saving performance, but also easily maintained.

(ii) An isolation wall and an electric isolation gate should be placed in the middle of the sump so that the pumping station can still operate normally in the event of an abnormal situation [3]. When the isolation gate is closed, the sump transforms into two smaller sumps, which form a unified production system when the isolation valve is open.

(iii) The operating platform of the pumping station should be placed on the ground to avoid leakage.

4. Operation of municipal rainwater and sewage pumping stations

4.1. Management of diving equipment

Immersible pumps are often used in municipal rain and sewage united pump stations. There are various types of diving equipment installed in the pumping station. Usually, the current of the equipment set in the middle is higher than that of the equipment set at the sides, and the current value may exceed 50%. If the equipment on both sides starts first, and the equipment in the middle cannot start normally. This means that the water inlet and outlet parameters of the pump station are not suitable. When the water outlet system on both sides of the pumping station fails, the water resistance value will increase significantly, which results in a high voltage, leading to power outages. There are many types of problems with mid-position devices, which is described below.

4.1.1. Waste clogging

The accumulation of sundries in the water inlet and outlet pipes can damage the components of the equipment and cause failures, or lead to high current and voltage. Therefore, it is necessary to deal with the waste accumulated in the water inlet and outlet pipes regularly.

4.1.2. Loss of power to sewerage

Most of the equipment in the pump station is a submersible pump unit and an axial flow pump unit. Among them, the submersible unit is in the water for a long time, and it will vibrate violently when in use, with a relatively large amplitude, which makes it prone to wear and tear and electrical damage, where circuits often fail to function properly. If this condition is ignored when starting the equipment, it will lead to failure problems of the drainage equipment. Therefore, when operating and managing diving equipment, it is necessary carefully investigate hidden dangers to ensure the normal operation of water supply and drainage equipment [4].

4.1.3. Loss of water vapor

Through daily inspections, it was found that the immersible pumps were worn out during operation, some axial flow units had been severely damaged, and the water vapor loss exceeded 50%. If this issue is not resolved, it will cause serious damage to the equipment. Therefore, it is important to inspect the equipment's operation status and make sure that the equipment is operating normally.

(1) Cleaning equipment operation management

The main function of the cleaning equipment of the municipal rainwater sewage pumping station is to prevent waste from entering the pipeline and prevent water supply and drainage equipment failures [5]. In terms of cleaning equipment, some local brands and foreign brands have better performance but are expensive. Although some ordinary domestic brands are relatively cheaper, their quality cannot be guaranteed. If the cleaning equipment lacks good power system protection, it will fail frequently [6]. Therefore, we must strengthen the operation and management of cleaning equipment. On one hand, we must choose appropriate cleaning equipment according to the actual situation. On the other hand, we must clean the pipelines more frequently and observe the accumulation of waste in the pipeline to ensure that the waste can be cleaned up in time [7].

(2) Operation management of electromechanical equipment

The number of electromechanical equipment in the municipal rainwater sewage pumping station is increasing year by year, and the equipment has been continuously perfected and are becoming increasingly reliable. However, there are some frequently encountered faults in the operation of municipal rainwater and sewage pumping stations.

The first problem is that the electrical connection points of electromechanical equipment are continuously heated. When the equipment operates for long periods of time, heat will be generated, the contact surface of the connection point will continue to shrink, and electrical corrosion will occur. If this problem is not resolved, the equipment will be damaged. Therefore, it is necessary inspect the operation of electromechanical equipment frequently in order to identify and deal with the problems found in time.

The second problem is that the electrical values of electromechanical equipment does not necessarily conform to conventional requirements. After an electromechanical equipment has been in operation for some time, the voltage and current values may suddenly increase or decrease [8]. Therefore, it is necessary to set the electrical values for electromechanical equipment. Once the current and voltage fluctuate, the circuit will be automatically protected, which significantly reduces the occurrence of power outages. For this reason, the operation and management personnel must do a good job in the daily inspection, so as prevent to safety accidents.

With the continuous development of science and technology, the operation pumping stations is becoming increasingly automated, and the management concept and methods have become more and more advanced [9]. To this end, through the establishment of an automatic operation management system, all the electromechanical equipment in the pumping station can be incorporated into the system. With the help of computer technology, network technology, measurement and control technology, and industrial control technology, a management and control system integrating communication, control and management can be built to realize automatic management and control. For example: A municipal rain and sewage united pumping station adopts a distributed electromechanical equipment operation management and control system. The components of the system mainly include the information layer, the field control layer, and the monitoring layer. A control room is used to monitor the various electromechanical equipment in the pumping station in real time [10]. There are usually two ways to control electromechanical equipment: manual and automatic. Each electromechanical equipment is equipped with a local control box with a manual and automatic switch. At the same time, in order to fully connect the pumping station to the sewage treatment plant, it is necessary to ensure that the operation of the electromechanical equipment is consistent with the sewage treatment plant, so as to coordinate the operation of pumping stations and sewage treatment plants.

5. Conclusion

In conclusion, when designing a municipal rainwater and sewage pumping station, it is necessary to reduce the investment and construction cost of the pumping station as much as possible while ensuring the efficiency of the pumping station. At the same time, it is necessary to comprehensively consider the convenience of subsequent operation and management, in order maximize the value of the
pump station.

Disclosure statement

The author declares no conflict of interest.

References

[1] Wang J, 2022 Design and Operation Analysis of Tongxiang Municipal Sewage Pumping Station Expansion and Renovation Project. China Survey and Design, 2022(01): 93–96.

[2] Zheng S, Shen B, 2021, Design of Monitoring System for Sewage Pumping Station Based on OPC UA. Mechatronics, 27(06): 19–24.

[3] Liu Z, Tan X, Chen Y, 2021, Evaluation and Diagnosis of Urban Sewage Pipe Network Based on Water Quantity Analysis and Node Monitoring. China Water Supply and Drainage, 37(17): 32–37.

[4] Tang J, 2021, Intelligent Operation and Maintenance Management of Decentralized Integrated Rainwater and Sewage Pumping Stations. Wisdom China, 2021(Z1): 120–121.

[5] Wu J, 2020, Exploration and Analysis of Rainwater and Sewage Entering Corridors in Urban Comprehensive Pipe Corridors. Theoretical Research on Urban Construction (Electronic Edition), 2020(16): 100.

[6] Li Z, Yang L, Zheng B, Discussion on Sponge City Scheme Design in Sewage Pumping Station Project. Urban Road Bridge and Flood Control, 2019(05): 178–180 + 22.

[7] Yuan M, 2021, Analysis and Selection of Deodorization Process for Municipal Drainage Pumping Stations. Zhonghua Construction, 2021(17): 218–219.

[8] Wang J, 2022, Design and Operation Analysis of Tongxiang Municipal Sewage Pumping Station Expansion and Renovation Project. China Survey and Design, 2022(1): 93–96.

[9] Shen Y, Wang J, Chen G, 2022, Design and Application of Dissolved Air Flotation Technology in Advanced Treatment of Municipal Sewage. Liaoning Chemical Industry, 2022(9): 51.

[10] Lu W, 2022, Design of Rainwater Pumping Station and Initial Rain Storage Tank in Beijing-Tianjin Cooperation Demonstration Area. Urban Roads, Bridges and Flood Control, 2022(11): 125–128.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Analysis of Concrete Crack Treatment Technologies in Buildings

Wenyu Zheng*

Qingdao Special Steel Co., Ltd., Qingdao 266409, Shandong Province, China

***Corresponding author:** Wenyu Zheng, WenyuZheng001@163.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: With the continuous development of civil engineering, concrete crack treatment technology has become an important research field. This paper proposes treatment techniques for different types of cracks, including the prevention and repair of surface cracks, the reinforcement and grouting of structural cracks, and the design and construction of controlled cracks through the analysis of the causes and classification of concrete cracks. The methods and suggestions proposed in this paper are practical and can improve the quality and safety of buildings.

Keywords: Civil engineering; Concrete cracks; Construction treatment technology; Structural damage; Safety hazards

Online publication: July 28, 2023

1. Introduction

It is crucial to treat concrete cracks in order to ensure the quality and safety of buildings. Therefore, this paper aims to comprehensively analyze the causes and classification of concrete cracks and the treatment techniques for different types of cracks. Through comprehensive research and case studies, effective treatment methods and suggestions are proposed to help solve problems related to concrete cracks. A deep understanding and application of these technologies will help improve the reliability and durability of buildings.

2. Causes and classification of concrete cracks

2.1. Causes of concrete cracks

There are causes of concrete cracks can be divided into two categories: internal and external. Internal factors include concrete shrinkage, temperature changes, material inhomogeneity, internal stress, etc., which cause stress concentration during curing and use, which leads to the formation of cracks. External factors include earthquakes, foundation settlement, load action, moisture infiltration, etc., in which the pressure and deformation exerted on the concrete structure by these external forces lead to the formation of cracks [1].

2.2. Classification and characteristics

Concrete cracks can be divided into several types depending on the nature and morphology of cracks. Common types include shrinkage cracks, temperature cracks, fractures, spalling cracks, and structural cracks. Shrinkage cracks are caused by the shrinkage of concrete during the drying and curing process, and they are usually presented as fine surface cracks. Temperature cracks are caused by thermal expansion and contraction of concrete under temperature changes, and the cracks appear as long linear cracks. Fractures are network cracks formed on the surface of concrete, mainly due to insufficient fracture toughness or stress

concentration of concrete (**Figure 1**). Spalling cracks are cracks formed by spalling of the concrete surface, usually caused by prolonged usage, chemical reaction, or freeze-thaw cycles. Structural cracks are major cracks in concrete structures and can be caused by loading, deformation, or improper structural design [2-4].

Figure 1. Cracking type of concrete crack

3. The construction treatment technology of surface cracks

3.1. Precautions

During the construction process, taking precautionary measures can effectively reduce the occurrence of surface cracks. Firstly, it is important to control the water-cement ratio of the concrete so that the concrete will not be too dry or too wet. Secondly, the crack resistance and durability of concrete can be improved by using appropriate concrete crack resistance materials and reinforcements [5-8]. In addition, the humidity and temperature of the construction environment should be well-controlled to prevent quick drying or excessive temperature changes. There are several techniques to treat surface cracks. Firstly, a layer of sealer or coating can be applied onto the surface of the concrete to increase its crack resistance and durability. Secondly, small cracks can be treated by filling the cracks with polymer repair materials, and the surface can be flattened by polishing and leveling to ensure a proper finish. At the same time, waterproofing techniques like waterproof coatings or permeable waterproofing agents can be applied to protect the concrete from moisture erosion and reduce the possibility of cracks.

3.2. Surface treatment technology

Common surface treatment techniques include coating, sealing, and polishing. Coating provides an additional protective layer to the concrete surface. The coatings used can be polymer coatings, epoxy coatings, or other special coatings that provide excellent crack resistance and durability [9-12]. The coating forms a protective film that prevents moisture and harmful substances from penetrating into the concrete, thus preventing the formation of cracks. Sealers are applied onto the surface of concrete to fill fine cracks and improve the impermeability and crack resistance of concrete. Commonly used sealers include polymer sealers, silicate sealers, etc. The sealer fills cracks and penetrates into the concrete, creating a protective film that provides additional durability and crack resistance. Polishing flattens and smoothens the concrete

surface and gives a glossy finish. Polishing can not only repair fine cracks, but also improve the hardness and wear resistance of the concrete surface. The polished surface is not only aesthetically pleasing, but also easier to clean and maintain.

3.3. Filling and patching techniques

Filling and patching are commonly used to treat cracks on the surface of concrete, which can repair the existing fine cracks and restore the flatness and beauty of the concrete surface. Some commonly used fillers include polymers, epoxy resins, cementitious fillers, etc. These materials have good adhesion and filling and are able to fill small cracks and form strong bonds with concrete surfaces. The procedure of concrete filling is as follows: First, the area of the cracks are cleaned, and debris and loose concrete particles are removed; then, a suitable filler is used to fill the cracks depending on the width and depth of the crack [12-15]. Filling can be done by hand or by injected using an injection device to ensure that the repair material fills the cracks completely and bonds well with the concrete; lastly, the repaired area is flattened and smoothened. The advantage of filling and repair technology is that it can effectively repair small cracks and improve the flatness and aesthetics of concrete surfaces. In addition, the selection of fillers and filling method should also be reasonably evaluated and decided according to the nature of cracks and the environment to ensure the best effect of the repair.

3.4. Waterproof treatment technology

Waterproof treatment technology plays an important role in the treatment of concrete cracks by preventing moisture penetration and erosion, and prevents the formation and expansion of cracks. Some commonly used waterproofing techniques are waterproof coatings and permeable waterproofing agents. Waterproof coating is a coating applied to the surface of concrete with waterproof properties. These coatings can form a waterproof membrane that prevents moisture from penetrating into the interior of the concrete. Waterproof coatings can be divided into two categories: rigid coatings and elastic coatings. Rigid coatings are suitable for flat concrete surfaces such as floors and walls. Elastomeric coatings are suitable for concrete structures that require high elasticity and durability, such as basements and bridges. Permeable waterproofing agents are chemicals that penetrate into the interior of concrete and fill in fine pores. These waterproofing agents are able to react with the cement components in the concrete to form a water-resistant gel that prevents moisture from penetrating. Permeable waterproofing agents do not change the appearance or surface texture of concrete and have good durability.

4. Treatment technology for structural cracks

4.1. Structural reinforcement and strengthening

The purpose of treatment of structural cracks is to restore the strength and stability of the concrete. A commonly used treatment technique structural reinforcement and strengthening. Structural reinforcement treats cracks by increasing the bearing capacity of concrete structures. A commonly used reinforcement is rebar. This involves drilling holes around the cracks and injecting epoxy binder, then inserting rebar into the holes to form a rebar reinforcement band. This increases the strength and stiffness of the structure and prevents the spread of cracks. In addition, high-strength materials such as fiber-reinforced composites (FRP) can also be used for reinforcement, which provides additional strength and stiffness by attaching them to the surface of the structure. Structural strengthening technology is used to improve the stress performance of the structure and prevent the formation of cracks [16-17]. A common approach is to add shear walls, reinforcement beams or reinforcement columns to concrete structures, etc. This can change the force transfer path of the structure, reduce the stress concentration at the crack, and improve the seismic performance and stability of the structure as a whole. When selecting and applying structural reinforcement

and strengthening technology, it is necessary to comprehensively consider factors such as the type of structure, stress state, and the nature and degree of cracks. Besides, the treatment should be performed in strict accordance with relevant specifications and requirements to ensure the effectiveness and safety of reinforcement and strengthening measures. Through reasonable structural reinforcement and strengthening technology, the crack resistance and overall stability of concrete structures can be improved, and their service life can be extended [18-19].

4.2. Grouting

Grouting is a commonly used structural crack treatment method where the crack is injected with a slurry to reinforce and repair concrete structures. This technology effectively restores the integrity and strength of the structure and prevents further expansion of cracks.

Some commonly used slurry in grouting include polymer, cement, epoxy resin, etc. These slurries have good flow rate and adhesion, and they can fill cracks and form a strong bond with the surrounding concrete.

The procedure of grouting is as follows: Firstly, the crack surface is cleaned, and loose concrete particles and debris are removed; then, holes are drilled in the crack and the appropriate grouting equipment is selected according to the width and depth of the crack; when grouting, it is important to control of grouting pressure and grouting speed to ensure that the slurry fully fills the cracks and bonds well with the concrete; lastly, the slurry material is left to solidify, and the repair and reinforcement process is completed. Cracks in concrete structures can be effectively filled and repaired by grouting, thus improving their strength and stability. However, it is necessary to select the appropriate slurry material and grouting method according to the situation. Besides, it is also important to strictly abide by the relevant specifications and requirements to ensure the treatment effect and the safety and reliability of the structure.

4.3. Prestressing

Prestressing is an advanced method for treating structural cracks that enhances the strength and stability of concrete structures by applying pre-applied tensile forces. The technology is suitable for structures that need to withstand large loads, such as long-span bridges, high-rise buildings, and other major projects. The main steps of prestressing technology are as follows: First, prestressed steel bundles are buried in the concrete structure, and these steel bundles will apply tension during the prestressing process; then, tensile force is applied through the tensioning equipment to prestress the steel beam; once the required degree of prestress is reached, the steel bundle is fixed to the anchor; lastly, the concrete will be compressed by the tensile force of the prestressed steel bundles, improving the strength and stability of the structure. The advantage of prestressing is that it can effectively control the cracks of the structure and reduce the width and propagation of cracks. Through prestressing, the tension in the structure can be offset or reduced, thereby reducing the stress on the concrete. This reduces the stress concentration of the concrete and reduces the formation and propagation of cracks. In addition, prestressing can improve the overall stiffness and seismic performance of the structure.

4.4. Structural modification and reconstruction

Structural modification and reconstruction are a comprehensive approach in dealing with structural cracks for severely damaged or loss-of-load-bearing concrete structures. Structural modification and reconstruction are performed to repair and rebuild structures so that they are in a secure and safe state. Structural modification involves adjusting and repairing existing structural components to increase their load-bearing capacity and stability. This may involve replacing damaged components, adding reinforcement, adjusting how members are connected, etc. Through these adjustments, the damaged parts

of the structure can be repaired, and its overall strength and stability can be improved. Structural reconstruction refers to the complete demolition and reconstruction of severely damaged or failed parts of a structure, which may include removing damaged concrete elements and rebuilding new structural components. The reconstruction process requires detailed design and calculations to ensure the accuracy and stability of the new components. Structural modification and reconstruction should be designed and performed by experienced engineers to ensure the safety and stability of the structure. Before modifications and reconstructions, a comprehensive structural assessment and analysis is required to identify the parts that need to be adjusted or rebuilt. At the same time, it is also important to adhere to relevant building codes and requirements to ensure the compliance and sustainability of the structure [20].

5. Crack treatment technologies

5.1. Design and construction of control joints

The design and construction of control joints is important in preventing and controlling cracks in concrete structures. Control joints guides and controls the formation and propagation of cracks by placing specific gaps in the concrete structure. When designing control joints, factors such as the type, size, stress state and expected deformation of the structure need to be considered. The construction of control joints usually involves creating slab gaps or cutting the concrete. Through reasonable design and construction of control joints, the width and number of cracks can be reduced, and the durability and overall performance of the structure can be improved.

5.2. Treatment of temperature and shrinkage cracks

Temperature and shrinkage are common causes of cracks in concrete structures. During temperature changes and shrinkage of concrete, internal stresses are generated, which trigger the formation of cracks. Methods for dealing with temperature and shrinkage cracks include controlling the temperature and humidity of the concrete, using bulking agents or additives to reduce concrete shrinkage, and considering the elasticity of the structure during the design and construction stages. Through effective temperature and shrinkage control, the incidence and degree of cracks can be reduced, and the integrity and stability of the structure can be maintained.

5.3. Prestressing and post-tensioning

Prestressing and post-tensioning are methods of controlling cracks in concrete structures by applying prestress or post-tension. Stresses and deformations in the structure can be reduced by applying tensile forces, thereby reducing the formation and propagation of cracks. Prestressing and post-tensioning are commonly used in large bridges, beam-and-column structures, and underground structures that are subject to large loads. Through reasonable prestressing and post-tensioning, the number and width of cracks can be effectively reduced, and the stability and crack resistance of the structure can be improved.

5.4. Reasonable construction process and sequence

Reasonable construction process and construction sequence play a key role in controlling cracks in concrete structures. During the construction process, appropriate measures need to be taken to reduce the stress concentration and deformation of the structure. This includes suitable pouring methods, adequate moist curing, and appropriate curing time. In addition, a reasonable sequence of construction is also a key factor, especially for large structures and complex shapes. Through reasonable construction process and sequence, stress and deformation in the structure can be reduced, thus preventing the formation and expansion of cracks.

In short, the design and construction of control joints, the treatment of temperature and shrinkage

cracks, the process of prestressing and post-tensioning, and the reasonable construction process and construction sequence are crucial to prevent cracks in concrete structures. They work together to effectively prevent and control the occurrence of cracks, improving the durability and overall performance of the structure. Besides the specific situation of the project should be considered, and relevant design specifications and construction requirements should be to ensure the construction quality and structural safety.

6. Conclusion

In conclusion, concrete crack treatment technology is of great significance in civil engineering. Through an in-depth analysis of the causes and classification of concrete cracks, as well as the treatment techniques for different types of cracks, cracks can be effectively prevented, controlled, and repaired. As a result, the stability and durability of concrete structures can be improved. However, in order to achieve good treatment results, it is necessary to comprehensively consider many factors such as the selection of materials, the rationality of design, and the utilization of construction technology. Future research should be carried out to better understand concrete cracks, promote technological innovation, and continuously improve the quality and sustainable development of civil engineering.

Disclosure statement

The author declares no conflict of interest.

References

[1] Han C, 2023, Research on the Cause and Prevention of Concrete Cracks in Civil Engineering. China Building Decoration and Decoration, 2023(07): 110–112.

[2] Wang Y, 2023, Analysis of Cracks Related to Concrete Floor Slab in Construction Civil Engineering. Development Orientation of Building Materials, 21(04): 60–62.

[3] Ji H, Luo N, 2023, Causes and Quality Control Analysis of Concrete Cracks in High-Rise Buildings. Urban Construction Theory Research (Electronic Edition), 2023(02): 131–133.

[4] Zhao J, 2022, Discussion on Key Technologies of Concrete Structure Construction in Civil Engineering Buildings. Engineering Technology Research, 7(16): 80–82.

[5] Zang P, 2021, Discussion on the Construction Treatment Technology of Concrete Cracks in Civil Engineering Buildings. Jushe, 2021(16): 33–34 + 86.

[6] Tang H, 2021, Exploration of Architectural Planning and Design Concept of Hefei Xinzhuang Primary School. Anhui Architecture, 28(8): 21–22.

[7] Liu Y, Ji M, 2021, Spatial Scale Thinking in the Planning and Layout of New Large-Scale Campus: A Case Study of the Planning and Architectural Design of the New Campus of Hebei Union University. Contemporary Architecture, 2021(8): 29–32.

[8] Qin Z, 2020, Research on Building Energy-Saving Campus Construction Based on Life Cycle Cost Theory. Industrial Innovation Research, 2020(8): 184–185

[9] Zhang Y, 2020, Research on Campus Planning and Architectural Design of Primary and Secondary Schools: A Case Study of Nanjing Foreign Language School Fangshan Branch. Urban Architecture, 2020(8): 52–57.

[10] Geng Y, 2020, Strategies for Improving Residential Planning and Design and Living Environment Under the New Situation. Housing & Real Estate, 2020(21): 46

[11] Sun H, 2020, Research on the Blended Learning Mode of University English in the Era of "Internet+". Science Teaching Journal, 2020(7): 27–28.

[12] Ge M, Cui W, Tang H, et al., 2020, Campus Model, Space Type, and Architectural Construction: A Seminar on Shenzhen Campus Planning and Design of Chinese University of Hong Kong. Architectural Journal, 2020(3): 99–111.

[13] Sun Y, 2020, Exploration and Thinking on Primary and Secondary School Campus Planning and Architectural Design. Housing & Real Estate, 2020(9): 82–83.

[14] Zhang L, Chen J, 2020, A Brief Analysis of the Modern Interpretation of Regional Culture in Campus Architectural Design: A Case Study of Campus Planning and Design of Guangxi University for Nationalities. Architecture and Culture, 2020(3): 90–91.

[15] He T, 2022, Analysis of the Characteristics and Sense of the Times of School Buildings: A Case Study of Zengcheng District Experimental Middle School of Guangzhou. Urban Architecture, 2022(24)

[16] Yue L, 2023, Discussion on Campus Architecture Design Based on humanized Design Concept. China Architectural Decoration, 2023(5): 109–111.

[17] Huang X, 2022, Strengthening Design of Building Structure in Renovation of Old Residential Area. China Housing Facilities, 2022(7): 34–36.

[18] Li J, 2021, Strategies to Improve Building Safety in Building Structure Design. Commodity and Quality, 2021(19): 121.

[19] Zhang H, Lan Q, Niu B, 2022, Application of Wood Structure in Canadian School Architecture. New Construction, 2020(06): 110–113.

[20] Wang Y, 2010, Design Concept of School Building. Basic Education Curriculum, 2010(04): 78.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 4
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Ecological Design of Expressway Based on the Perspective of Landscape Ecology

Tengfei Gong*

China Merchants Chongqing Communications Technology Research & Design Institute Co., LTD., Chongqing 400067, China

***Corresponding author:** Tengfei Gong, 1213785973@qq.com

Copyright: © 2023 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The construction and operation of expressways will also bring a series of environmental and ecological problems, such as land use conflicts, ecological damage, environmental pollution, etc. In order to solve such problems, it is necessary to strengthen the application of landscape ecology. From the perspective of landscape ecology, this paper first introduces the impact of expressways on the ecological environment, and then analyzes the principles of expressway ecological landscape design. Landscaping, ecological environment, customer satisfaction, and other aspects have all performed well, with an optimization rate of over 90%. Future expressway design can strengthen the application of landscape ecology.

Keywords: Expressway; Landscape design; Service area

Online publication: July 28, 2023

1. Introduction

Landscape ecology is a discipline that studies the spatial pattern of landscapes, ecological processes, and their relationship with ecological stress. It emphasizes the idea of holism, taking the biological and abiotic factors of the ecosystem and human activities as a whole, and studying their interaction, influence, and evolution. With the development of social economy and the increase of road traffic, the construction of expressways has become an important symbol of the development of modern cities. However, the construction of expressways often has negative impacts on the ecological environment, such as loss of biodiversity, changes in land use patterns, and deterioration of the ecological environment. In order to reduce these negative impacts, it is important to explore the ecological design of expressways.

2. The impact of expressways on the ecological environment

2.1. Change of land use

The construction of expressways requires a large amount of land, which may result in the change of land use of surrounding lands [1]. For example, ecosystems such as forests, wetlands, and wildlife habitats may be traversed or destroyed by highways. This can change the migration routes of wildlife, affecting the survival and reproduction of species.

2.2. Cutting off the ecological corridor

Highways often cut off the migration routes of organisms, especially the ability of wild animals to find food, water sources, or escape predators in their natural environment [2], which may lead to the decline in the number of species and may even cause some species to become endangered.

2.3. Noise and pollution

Highways generate noise pollution and other forms of pollution, which may impact the surrounding ecosystem [3]. For example, noise can affect the behavior of wildlife, while exhaust emissions can negatively impact air quality.

2.4. Water resources and soil erosion

The construction of highways may affect the surrounding water resources, such as the flow of groundwater and surface water. In addition, soil erosion during construction and road maintenance may also have an impact on the ecological environment.

2.5. Impact of human communities

The construction of expressways may change the lifestyles of people in nearby communities, such as changing the landscape, affecting cultural and historical relics, etc [4]. In addition, the noise and pollution of highways may also affect the quality of life of local residents.

2.6. Economic factors

The construction of expressways usually promotes the development of the local economy, but at the same time it may also lead to problems such as rising prices and increasing resource consumption.

3. Principles of ecological design of expressways based on the perspective of landscape ecology

Based on the perspective of landscape ecology, expressways should be designed based on the principles below [5-9].

3.1. Holistic and systematic

The relationship between the expressway and the surrounding ecological environment should be considered from a systematic point of view, as well as its impact on the structure and function of the ecosystem.

3.2. Protect and restore the ecological environment

When designing highways, it is important to protect and restore the surrounding ecological environment as much as possible to avoid damaging the natural environment. For example, the existing vegetation and ecosystem should be protected, and measures should be taken to restore the affected ecological environment.

3.3. Ecological diversity

It is important to respect and protect biodiversity and provide a suitable living environment for all kinds of creatures. For example, living spaces should be created for different types of animals and plants by designing diverse ecological environments, including wetlands, woodlands, grasslands, etc.

3.4. Continuity and connectivity

Ensure ecosystem continuity and connectivity. In the design of expressways, the migration and activities of wild animals should be considered. In addition, the continuity of hydrological and biological processes within the ecosystem should be ensured.

3.5. Sustainability

Considering the long-term use and operation of the expressway, it is important to focus on saving resources and reducing environmental pollution while ensuring its long-term ecological benefits. For example, use environmentally friendly materials, optimize designs to reduce maintenance costs, and reduce

environmental impact.

3.6. Local characteristics

In the design of expressways, it is important to respect the local natural and cultural characteristics and integrate local characteristics into the design. For example, in terms of vegetation selection, local plants can be prioritized in order to enhance ecological diversity and local characteristics.

3.7. Public participation and transparent decision-making

During the design and construction process, public participation is encouraged to ensure transparency in the decision-making process. This helps to ensure the rationality and feasibility of ecological design, while enhancing public understanding and support for the project.

3.8. Prevention and minimization

It is important to prevent and minimize damage to the ecological environment during the design and operation of the expressway. For example, a comprehensive ecological environment investigation and assessment can be conducted in advance, and preventive measures can be formulated, and the operation of the expressway should be monitored while performing restoration measures to minimize the impact on the ecological environment.

3.9. Collaboration and learning

Collaboration among relevant institutions and professionals can also improve the ecological design. In addition, design methods should be continuously learned and improved to adapt to the ever-changing needs and requirements of the ecological environment.

By following the above principles, the ecological design of expressways will be more in line with the requirements of landscape ecology, which will help protect and restore the ecological environment, improve biodiversity, promote sustainable development, and enhance public satisfaction and acceptance. At the same time, through collaborating with relevant parties, the practicality and research of ecological design can be continuously improved.

4. Case analysis

4.1. Project overview

A highway is an important arterial road connecting city A and city B, which is of great significance for promoting regional economic development and strengthening exchanges and cooperation between cities. In order to meet traffic demand and improve road traffic capacity and service, a service area can be built between City A and City B. The project includes the service area, supporting facilities, charging system, etc. The total investment is expected to be about 500 million yuan, including service hall, monitoring room, power distribution room, and other facilities, as well as squares and parking lots inside and outside the service area, including water supply and drainage system, power supply system, communication system, fire protection system, monitoring equipment, etc., and the docking with the existing expressway management center. The project is expected to achieve 100 million yuan in toll revenue within the first year of operation, while bringing job opportunities and economic development opportunities to surrounding areas. The project has started in 2022, and the construction period is expected to be 2 years.

4.2. Design ideas

The project follows the design concept of green, intelligent, safe, and convenient, and it also aims to provide efficient, reliable, and safe services, while fully considering environmental protection and reducing the

impact on the surrounding ecological environment [10-12]. The main body of the service area is made of environmentally friendly materials, and a rainwater collection system is designed to realize resource recycling. The service system adopts intelligent identification technology to improve the efficiency of vehicle traffic and reduce management costs. Monitoring equipment is installed inside and outside the service area to monitor vehicle traffic in real time to ensure safety.

After the project is completed and put into operation, the service area will be expanded or upgraded according to the actual situation to meet the development of traffic demand. At the same time, it will also strengthen cooperation with surrounding cities to promote the improvement and development of the expressway network. This project will help to improve the traffic capacity and service level the expressway, relieve traffic pressure and promote regional economic development. At the same time, it will also create employment and economic development opportunities for surrounding areas and enhance the city's image and competitiveness. During the implementation of the project, environmental protection issues will be fully considered, and effective measures will be taken to reduce the impact on the surrounding ecological environment. At the same time, we will also work closely with the local government and relevant departments to ensure the smooth implementation and operation of the project.

4.3. Design content

4.3.1. Optimize route design

In the route design, ecologically sensitive areas, such as nature reserves, wetland parks, etc. are avoided. At the same time, it is important to avoid cutting down a large number of trees and destroying land use types, so as to reduce the damage to the ecological environment.

4.3.2. Water resources protection

The protection and utilization of water resources are taken into consideration in the design. For example, pollution and waste of surface water and groundwater are avoided through rational design of drainage systems. In addition, rainwater collection and utilization is also a good measure to save water resources.

4.3.3. Energy saving and environmental protection

Energy saving and environmental protection are considered in the design. For example, energy-saving lighting systems and renewable materials are used, and solar energy facilities are installed to reduce energy consumption and environmental pollution.

4.3.4. Landscaping

Landscaping is considered in the design to blend the highway with its surroundings. For example, through the integration of vegetation greening, landscape design, and cultural elements, the expressway becomes a beautiful landscape, and green belts are set up on both sides of the road to increase the vegetation coverage [13]; ecological corridors along the route are protected and restored; plant species suitable for the local climate and soil conditions are selected [14] and local cultural elements are integrated, which enhances the aesthetics and uniqueness of the road; public participation and education are strengthened to improve environmental protection awareness.

4.3.5. Long-term monitoring and maintenance

Long-term monitoring and maintenance work is carried out during the operation of the expressway. For example, vegetation restoration and facility operation status are checked regularly, problems are identified in time, and repairs and improvements are carried out, which will help maintain the ecological and sustainable development of expressways.

By adopting the above-mentioned ecological design strategy [15], the harmonious symbiosis between the expressway and the surrounding environment is realized, and the expected effect is illustrated in **Figures 1–3**.

Figure 1. Rendering 1

Figure 2. Rendering 2

Figure 3. Rendering 3

4.4. Effect analysis

Table 1. Expected effects of the project

Serial number	Indicator	Value	Remark
1	Average vehicle speed	20 km/h	10% higher than the original service area
2	Vehicle capacity	300 vehicles/hour	20% higher than the original service area
3	Energy consumption reduction	30%	Through the use of energy-efficient equipment and technologies
4	Noise level reduction	5 dB	Noise reduction facilities by design
5	Air quality improvement	Reduce $PM_{2.5}$ concentration by 20 %	Through green belts and air purification facilities
6	Improved landscaping	90%	Through ecological landscape design and plant configuration
7	Improved air circulation in the service area	80%	Natural ventilation system by design
8	Increased employee productivity in the service area	15%	By optimizing workflow and adopting intelligent management system
9	Increased customer satisfaction	95%	By optimizing the service process and providing convenient payment methods

Based on **Table 1**, it is clear that the service area designed from the perspective of ecological landscape will be optimized in many aspects, including average vehicle passing speed, vehicle capacity, energy consumption reduction, noise level reduction, air quality, landscaping, and air circulation in the service area. Besides, the work efficiency of employees in the service area and customer satisfaction will be improved, and the degree of landscaping will increase by 90%.

5. Conclusion

Under the idea of landscape ecology, scientific and reasonable ecological design strategies can effectively reduce the impact of highway construction on the ecological environment and realize the harmonious coexistence of man and nature. As a comprehensive discipline, landscape ecology provides important theoretical and methodological support for the ecological design of expressways. In the ecological design of expressways, we should start from the perspective of landscape ecology and comprehensively consider ecological, cultural, economic, and social factors to realize the harmonious coexistence of expressways and surrounding environments. In an ecological design, it is crucial to emphasize protecting the ecological environment, improving the stability and sustainability of the ecosystem, and creating a healthier and more livable living space for human beings.

In the future development, the ecological design of expressways should focus on the aspects below.

(1) Advocate the concept of green design, emphasizing ecological protection and sustainable development
In the design and construction of expressways, it is necessary to minimize the damage and pollution to the ecological environment, pay attention to the protection and utilization of natural resources, and adopt sustainable ecological design methods and technologies.

(2) Strengthen ecological restoration and reconstruction
For the ecological environment that has been destroyed, effective ecological restoration and reconstruction measures should be taken, such as vegetation restoration, wetland protection, and biodiversity protection.

(3) Promote the development of intelligent and green transportation
By adopting advanced intelligent technology and green traffic concepts, the traffic efficiency and management level of expressways can be improved, and problems such as traffic congestion and environmental pollution can be reduced.

(4) Promote multidisciplinary integration
The ecological design of expressways involves knowledge and technology of many disciplines, such as landscape design, ecology, environmental engineering, traffic planning, etc. It is necessary to strengthen the cross-integration of various disciplines to promote the development of ecological design of expressways.

In short, the ecological design of expressways based on the perspective of landscape ecology is one of the important ways to achieve sustainable development. By taking reasonable ecological design measures, we can effectively protect the ecological environment, improve traffic efficiency and the people's quality of life quality of life, and contribute to the sustainable development of the city.

Disclosure statement

The author declares no conflict of interest.

References

[1] Cui Y, 2019, The Impact of Subgrade Construction on the Ecological Environment of Expressways. Heilongjiang Transportation Science and Technology, 42(11): 22–23.

[2] Zhu E, 2018, Application Research of Remote Sensing Interpretation in the Evaluation of Expressway Ecological Environment. Shanxi Transportation Science and Technology, 2018(04): 123–125.

[3] Peng Y, 2016, Research on Theory and Method of Ecological Environment Evaluation of Mountain Expressway, dissertation, Chongqing Jiaotong University.

[4] Wang Q, 2015, Detection of Changes in the Ecological Environment of Mountainous Highways Based on RS and GIS, dissertation, Chongqing Jiaotong University.

[5] Xia R, 2017, Research on Landscape Planning and Design of Expressway Ecological Green Corridor Based on "Relational Coupling Method", dissertation, Anhui Agricultural University.

[6] Cai A, Ke S, 2015, Research on the Technology of Expressway Ecological Landscape Planning and Design. Qinghai Transportation Science and Technology, 2015(06): 5–8.

[7] Jiang L, 2015, Research on Ecological Landscape Design of Shaoyang Expressway, dissertation, Central South University of Forestry and Technology.

[8] Jiang Y, 2014, Research on Ecological Environment Restoration and Landscape Comprehensive Design of Expressway, dissertation, South China University of Technology.

[9] Xu L, 2022, Research on Expressway Landscape Planning and Design Based on Ecological Concepts. Wisdom China, 2022(02): 76–78.

[10] Hou F, Lu X, Jia Y, et al., 2018, Talking about the Ecological Landscape Design of Expressways. Jushe, 2018(23): 111.

[11] Zhang D, 2018, Research on the Standards of Ecological Expressway Landscape Design. Science and Technology Innovation and Application, 2018(02): 110–111.

[12] He Y, 2017, Design and Evaluation Analysis of Ecological Landscape Forest Belt on Expressway, dissertation, South China University of Technology.

[13] Du H, 2018, Ecological Aesthetics and Modern Highway Landscape Design, dissertation, Kunming University of Science and Technology.

[14] Han Z, 2015, Discussion on Greening Ecological Engineering of Shaanxi Expressway Toll Station, dissertation, Chang'an University.

[15] Wang F, 2014, Relationship between Expressway Service Area and Auxiliary Facilities and Landscape. North Communications, 2014(S2): 75–77.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author Guidelines

Before your submission, please check that your manuscript has been prepared in accordance to the step-by-step instructions for submitting a manuscript to our online submission system. We recommend that you keep this page open for your reference as you move through the submission process.

If there are any differences in author guidelines between the print and online version, it is recommended that authors refer to the online version for use.

Manuscript Format

Journal of Architectural Research and Development accepts manuscript that is in MS Word or LaTeX format. All manuscripts must be written in clear, comprehensible English. Both American and British English are acceptable. Usage of non-English words should be kept to a minimum and all must be italicized (except for e.g. and i.e.) If you have concerns about the level of English in your submission, please ensure that it is proofread before submission by a native English speaker or a scientific editing service.

Cover letter

All submissions for *Journal of Architectural Research and Development* should include a cover letter as a separate file. A cover letter should contain a brief explanation of what was previously known, the conceptual advancement with the findings and its significance to broad readership. The cover letter is confidential and will be read only by the editors. It will not be seen by reviewers.

Title

The title should capture the conceptual significance for a broad audience. The title should not be more than 50 words and should be able to give readers an overall view of the paper's significance. Titles should avoid using uncommon jargons, abbreviations and punctuation.

List of Authors

The names of authors must be spelled out rather than set in initials with their affiliations footnoted. Authors should be listed according to the extent of their contribution, with the major contributor listed first. All corresponding authors (maximum 2) should be identified with an asterisk. Affiliations should contain the following core information: department, institution, city, state, postal code, and country. For contact, email address of only one corresponding author is expected within the manuscript. Please note that all authors must see and approve the final version of the manuscript before submitting.

Abstract

Articles must include an abstract containing a maximum of 200 words. The purpose of abstract is to provide sufficient information for a reader to choose either to proceed to the full text of the article. After the abstract, please give 3-8 key words; please avoid using the same words as those already used in the title.

Section Headings

Please number all section headings, subheadings and sub-subheadings. Use boldface to identify major headings (e.g. **1**, **2**, **3**, etc.) and subheadings (e.g. **1.1**, **1.2**, **2.1**, **2.2** etc.) For the sub-subheadings, please distinguish it further using non-boldface numbers in parenthesis (e.g. (1), (2), (3), etc.)

Introduction

Introduction should provide a background that gives a broad readership an overall outlook of the field and the research performed. It tackles a problem and states its important regarding with the significance of the study. Introduction can conclude with a brief statement of the aim of the work and a comment about whether that aim was achieved.

Materials and Methods

This section provides the general experimental design and methodologies used. The aim is to provide enough detail to for other investigators to fully replicate your results. It is also required to facilitate better understanding of the results obtained. Protocols and procedures for new methods must be included in detail to reproduce the experiments.

Ethics

Ethics information, including IACUC permit numbers and/or IRB name, if applicable. This information should be included in a subheading labelled "Ethics Statement" in the "Methods" section of your manuscript file, in as much detail as possible.

Results

This section can be divided into subheadings. This section focuses on the results of the experiments performed.

Discussion

This section should provide the significance of the results and identify the impact of the research in a broader context. It should not be redundant or similar to the content of the results section.

Conclusion

Please use the conclusion section for interpretation only, and not to summarize information already presented in the text or abstract.

Conflict of Interest

All authors are required to declare all activities that have the potential to be deemed as a source of competing interest in relations to their submitted manuscript. Examples of such activities could include personal or work-related relationships, events, etc. Authors who have nothing to declare are encouraged to add "No conflict of interest was reported by all authors" in this section.

Funding

Authors should declare all financial and non-financial support that have the potential to be deemed as a source of competing interest in relations to their submitted manuscript in this section. Financial supports are generally in the form of grants, royalties, consulting fees and more. Examples of non-financial support could include the following: externally-supplied equipments/biological sources, writing assistance, administrative support, contributions from non-authors etc.

Appendix

This section is optional and is for all materials (e.g. advanced technical details) that has been excluded from the main text but remain essential to readers in understanding the manuscripts. This section is

not for supplementary figures. Authors are advised to refer to the section on 'Supplementary figures' for such submissions.

Text

The text of the manuscript should be in Microsoft Word or Latex. The length of the manuscript cannot be more than 50000 characters (inclusive of spaces) or approximately 7000 words.

Nomenclature for genes and proteins

This journal aims to reach researchers all over the globe. Hence, for both reviewers' and readers' ease in comprehension, authors are highly encouraged to use the appropriate gene and protein nomenclature. Authors may prefer to utilize resources such as http://www.ncbi.nlm.nih.gov/gene

Figures

Authors should include all figures into the manuscript and submit it as 1 file in the OJS system. Reference to the "Instructions for Typesetting manuscript" is strongly encouraged. Figures include photographs, scanned images, graphs, charts and schematic diagrams. Figures submitted should avoid unnecessary decorative effects (e.g. 3D graphs) as well as be minimally processed (e.g. changes in brightness and contrast applied uniformly for the entire figure). It should also be set against a white background. Please remember to label all figures (e.g. axis etc.) and add in captions (below the figure) as required. These captions should be numbered (e.g. **Figure 1**, **Figure 2**, etc.) in boldface. All figures must have a brief title (also known as caption) that describes the entire figure without citing specific panels, followed by a legend defined as description of each panel. Please identify each panel with uppercase letters in parenthesis (e.g. A, B, C, etc.)

The preferred file formats for any separately submitted figure(s) are TIFF or JPEG. All figures should be legible in print form and of optimal resolution. Optimal resolutions preferred are 300 dots per inch for RBG coloured, 600 dots per inch for greyscale and 1200 dots per inch for line art. Although there are no file size limitation imposed, authors are highly encouraged to compress their figures to an ideal size without unduly affecting legibility and resolution of figures. This will also speed up the process of uploading in the submission system if necessary.

The Editor-in-Chief and Publisher reserve the right to request from author(s) the high-resolution files and unprocessed data and metadata files should the need arise at any point after manuscript submission for reasons such as production, evaluation or other purposes. The file name should allow for ease in identifying the associated manuscript submitted.

Tables, lists and equations

Tables, lists and equations must be submitted together with the manuscript. Likewise, lists and equations should be properly aligned and its meaning clear to readers. Tables created using Microsoft Word table function are preferred. Place each table in your manuscript file right after the paragraph in which it is first cited. Do not submit your tables in separate files. The tables should include a concise but sufficiently explanatory title at the top. Vertical lines should not be used to separate columns. Leave some extra space between the columns instead. All tables should be based on three horizontal lines to separate the caption, header and body. A few additional horizontal lines MAY be included as needed (example below). Any explanations essential to the understanding of the table should be given in footnotes at the bottom of the table. SI units should be used.

Supplementary information

This section is optional and contains all materials and figures that have been excluded from the entire manuscript. This information are relevant to the manuscript but remains non-essential to readers' understanding of the manuscript's main content. All supplementary information should be submitted as a separate file in Step 4 during submission. Please ensure the names of such files contain 'suppl. info'.

In-text citations

Reference citations in the text should be numbered consecutively in superscript square brackets. Some examples:

1. Negotiation research spans many disciplines [3, 4].
2. This result was later contradicted by Becker and Seligman [5].
3. This effect has been widely studied [1–3, 7].

Personal communications and unpublished works can only be used in the main text of the submission and are not to be placed in the Reference section. Authors are advised to limit such usage to the minimum. They should also be easily identifiable by stating the authors and year of such unpublished works or personal communications and the word 'Unpublished' in parenthesis.

E.g. (Smith J, 2000, Unpublished)

References

This section is compulsory and should be placed at the end of all manuscripts. Do not use footnotes or endnotes as a substitute for a reference list. The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should be excluded from this section.

For references in reference list, all authors must be stated. Authors referenced are listed with their surname followed by their initials. All references should be numbered (e.g. 1. 2. 3. etc.) and sequenced according to the order it appears as an in-text citation. References should follow the following pattern: Author(s) followed by year of publication, title of publication, full journal name in italics, volume number, issue number in parenthesis, page range and lastly the DOI (if applicable). If the referred article has more than three authors, list only the first three authors and abbreviate the remaining authors to italicized 'et al.' (meaning: "and others").

Journal

Journal article (print) with one to three authors

[1] Yao Y., Xia B. Application of Phase Frequency Feature Group Delay Algorithm in Database Differential Access. Computer Simulation, 2014, 31(12): 238-241.

Journal article (print) with more than three authors

[2] Gamelin F.X., Baquet G., Berthoin S., et al. Effect of high intensity intermittent training on heart rate variability in prepubescent children. European Journal of Applied Physiology, 2009, 105: 731–738.

Journal article (online) with one to three authors

[3] Jackson D., Firtko A., Edenborough M. Personal resilience as a strategy for surviving and thriving in the face of workplace adversity: a literature review. Journal of Advanced Nursing, 2009, 60(1): 1–9,

Journal article (online) with more than three authors

[4] Hargreave M., Jensen A., Nielsen T.S.S., et al. Maternal use of fertility drugs and risk of cancer in children—A nationwide population-based cohort study in Denmark. International Journal of Cancer, 2015, 136(8): 1931–1939.

Book

Book with one to three authors

[5] Schneider Z., Whitehead D., Elliott D. Nursing and midwifery research: methods and appraisal for evidence-based practice. 3rd edn. 2009, Elsevier Australia, Marrickville, NSW.

Book with more than three authors

[6] Davis M., Charles L., Curry M.J., et al. Challenging spatial norms. 2013, Routledge, London.

Chapter or Article in Book

[7] Knowles M.S. Independent study. In Using learning contracts. 1986, Jossey-Bass, San Francisco, 89–96.

Others

Proceedings of meetings and symposiums, conference papers

[8] Chang S.S., Liaw L. and Ruppenhofer J. (eds). Proceedings of the twenty-fifth annual meeting of the Berkeley Linguistics Society, February 12–15, 1999: general session and parasession on loan word phenomena. 2000, Berkeley Linguistics Society, Berkeley.

Conference proceedings (from electronic database)

[9] Bukowski R.M. Prognostic factors for survival in metastatic renal cell carcinoma: update 2008. Innovations and challenges in renal cancer: proceedings of the third Cambridge conference. Cancer, 2009, 115 (10): 2273, viewed 19 May 2009, Academic OneFile database.

Online Document with author names

[10] Este J., Warren C., Connor L., et al. Life in the clickstream: the future of journalism, Media Entertainment and Arts Alliance, 2008. viewed 27 May 2009, http://www.alliance.org.au/documents/foj_report_final.pdf

Online Document without author name

[11] Developing an argument n.d., viewed March 30 2009, http://web.princeton.edu/sites/writing

/Writing_Center/WCWritingResources.htm

Thesis/Dissertation

[12] Gale L. The relationship between leadership and employee empowerment for successful total quality management. 2000, University of Western Sydney.

Standard

[13] Standards Australia Online. Glass in buildings: selection and installation. AS 1288–2006. 2006, SAI Global database.

Government Report

[14] National Commission of Audit. Report to the Commonwealth Government, Australian Government Publishing Service, 1996, Canberra.

Government report (online)

[15] Department of Health and Ageing. Ageing and aged care in Australia, 2008, viewed 10 November 2008, http://www.health.gov.au/internet/main/publishing.nsf/Content/ageing

No author

[16] Guide to agricultural meteorological practices. 2nd edn, Secretariat of the World Meteorological Organization, 2010, Geneva.

Note: When referencing an entry from a dictionary or an encyclopedia with no author there is no requirement to include the source in the reference list. In these cases, only cite the title and year of the source in-text. For an authored dictionary/encyclopedia, treat the source as an authored book.

Submission Preparation Checklist

As part of the submission process, authors are required to check off their submission's compliance with all of the following items, and submissions may be returned to authors that do not adhere to these guidelines.

1. The submission has not been previously published, nor is it before another journal for consideration (or an explanation has been provided in Comments to the Editor).

2. The submission file is in OpenOffice, Microsoft Word, RTF, or WordPerfect document file format.

3. Where available, URLs for the references have been provided.

4. The text is single-spaced; uses a 12-point font; employs italics, rather than underlining (except with URL addresses); and all illustrations, figures, and tables are placed within the text at the appropriate points, rather than at the end.

5. The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines, which is found in About the Journal.

6. If submitting to a peer-reviewed section of the journal, the instructions in Ensuring a Blind Review have been followed.

Integrated Services Platform of International Scientific Cooperation

Innoscience Research (Malaysia), which is global market oriented, was founded in 2016.Innoscience Research focuses on services based on scientific research. By cooperating with universities and scientific institutes all over the world, it performs medical researches to benefit human beings and promotes the interdisciplinary and international exchanges among researchers.

Innoscience Research covers biology, chemistry, physics and many other disciplines. It mainly focuses on the improvement of human health. It aims to promote the cooperation, exploration and exchange among researchers from different countries. By establishing platforms, Innoscience integrates the demands from different fields to realize the combination of clinical research and basic research and to accelerate and deepen the international scientific cooperation.

Cooperation Mode

Clinical Workers

In-service Doctors

Foreign Researchers

Hospital

University

Scientific institutions

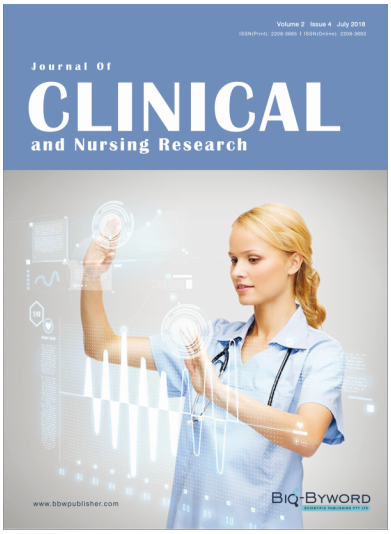
BIO-BYWORD
SCIENTIFIC PUBLISHING PTY LTD

OUR JOURNALS

The *Journal of Architectural Research and Development* is an international peer-reviewed and open access journal which is devoted to establish a bridge between theory and practice in the fields of architectural and design research, urban planning and built environment research.

Topics covered but not limited to:

- Architectural design
- Architectural technology, including new technologies and energy saving technologies
- Architectural practice
- Urban planning
- Impacts of architecture on environment



Journal of Clinical and Nursing Research (JCNR) is an international, peer reviewed and open access journal that seeks to promote the development and exchange of knowledge which is directly relevant to all clinical and nursing research and practice. Articles which explore the meaning, prevention, treatment, outcome and impact of a high standard clinical and nursing practice and discipline are encouraged to be submitted as original article, review, case report, short communication and letters.

Topics covered by not limited to:

- Development of clinical and nursing research, evaluation, evidence-based practice and scientific enquiry
- Patients and family experiences of health care
- Clinical and nursing research to enhance patient safety and reduce harm to patients
- Ethics
- Clinical and Nursing history
- Medicine

Journal of Electronic Research and Application is an international, peer-reviewed and open access journal which publishes original articles, reviews, short communications, case studies and letters in the field of electronic research and application.

Topics covered but not limited to:

- Automation
- Circuit Analysis and Application
- Electric and Electronic Measurement Systems
- Electrical Engineering
- Electronic Materials
- Electronics and Communications Engineering
- Power Systems and Power Electronics
- Signal Processing
- Telecommunications Engineering
- Wireless and Mobile Communication