Journal of Architectural Research and Development

Editor-in-Chief

S. Ravi

Anna University, India

BIO-BYWORD SCIENTIFIC PUBLISHING PTY LTD
(619 649 400)
Level 10
50 Clarence Street
SYDNEY NSW 2000

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

January 2023, Volume 7 Issue 1

Table of Contents

Call for papers – Journal of Architectural Research and Development

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

Submission open for March - 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**

With Warm Regards,
Editor in Chief
Dr. Ravi S.
Journal of Architectural Research and Development

Journal of Architectural Research and Development, 2023, Volume 7, Issue 1
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Research on Traffic Safety at Tunnel Entrance and Exit

Jiawen Chu*

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

***Corresponding author:** Jiawen Chu, chujiawen@qq.com

Abstract: Highway tunnel entrances have a high rate of expressway traffic accidents. In this paper, the reasons for the high incidence of traffic accidents at highway tunnel entrances are analyzed in detail, and corresponding solutions are proposed, hoping to provide some reference to relevant parties.

Keywords: Expressway; Tunnel entrance and exit; Traffic safety; Improvement measures

Online publication: January 5, 2023

1. Introduction

Expressway construction duration and operation safety are important standards that measure the development of a country's infrastructure. After the reform and opening-up, the construction of highways in China has undergone rapid development in recent years, especially in the middle and western regions. In the process of highway construction in Central and Western China, due to the complexity of landforms, tunnels have become a channel for highways to cross mountains. However, with the increasing number of tunnels, the frequency of traffic accidents at tunnel entrances and exits is also increasing [1]. Therefore, this is an issue that traffic engineering departments need to focus on and investigate, in particular the reasons that lead to the high incidence of traffic safety accidents at the entrance and exit of expressway tunnels so as to formulate reasonable and effective traffic management methods for the traffic operation at the entrance and exit of tunnels as well as provide security for traffic safety at these locations.

2. Influencing factors of traffic safety at the entrance and exit of expressway tunnels

A detailed analysis of the factors that affect the traffic safety at the entrance and exit of expressway tunnels can provide useful reference for solving the relevant problems and improving traffic operation efficiency.

2.1. Driver factors

2.1.1. Vision

At the entrance of highway tunnels, there are changes to the traffic environment, which have a significant influence on drivers. Using the visual characteristics of drivers for monitoring and control of the change of different indicators, it is possible to analyze the change in visual characteristics of drivers at the tunnel entrances and exits. By monitoring, it has been found that, at tunnel entrances and exits, there are changes to several indicators, including the driver's watching time and number of fixation (to the attention of a region), the number of scanning and scanning speed (pilot area) to access information, blink frequency, and eyes closure time (driver's fatigue) [2]. It should be emphasized that the speed of vehicles on the highway

is relatively fast, and the vehicles will advance a long distance in a very short time. When a driver's eye closure time continues to increase, traffic accidents occur easily (such as rear-end collision, hitting the guardrail, *etc*.).

The poor visual characteristics of drivers when they pass through the tunnel entrance and exit lead to visual fatigue, thus threatening driving safety. According to the survey, the anti-fatigue ability of drivers decreases with advanced age, and the change in eye closure time is most evident when drivers of different ages pass through the tunnel entrance and exit [3]. Therefore, when formulating relevant traffic management policies, it is necessary to fully consider the influence of age factor on eye closure time, so as to ensure sufficient distance for restoration of normal driving sight.

2.1.2. Bad driving behavior

Bad driving behavior will lead to a lot of traffic safety hazards, endangering traffic safety. Major violations at the entrance and exit of tunnels include overloading, speeding, drunk driving, illegal overtaking, insufficient safe distance from the vehicle in front, violation of traffic signs and lines, illegal parking, driving without following the lane, fatigue driving, *etc*. These reasons account for traffic safety accidents at tunnel entrances and exits (**Figure 1**).

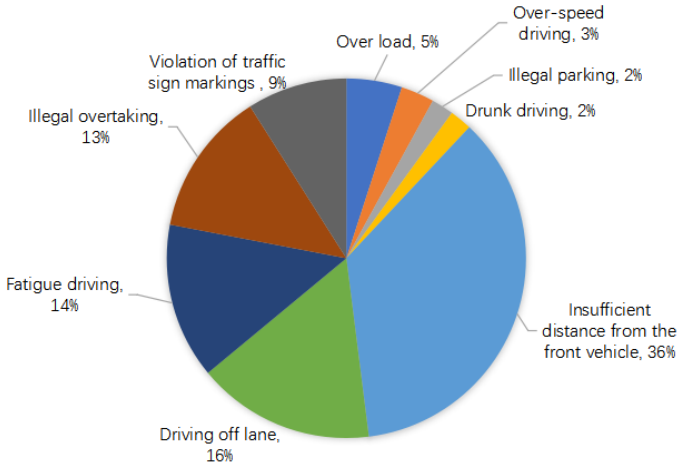


Figure 1. Statistical chart of proportion of different driving violations

Several inferences can be made from **Figure 1**.

(1) Driving without following the lane, insufficient safe distance, illegal overtaking at the tunnel entrance, and fatigue driving account for 79% of safety accident rates. Among them, insufficient safety distance between the vehicle in front accounts for the highest proportion and is the major cause of tunnel exit accidents. This also explains why rear-end collision tends to occur at tunnel exits.

(2) The proportion of traffic accidents caused by drunk driving is relatively low, which may be attributed to the implementation of strict drink-driving laws and regulations. Therefore, appropriate and strict laws and regulations are of great benefit to reducing the occurrence of traffic accidents.

(3) Fatigue driving accounts for a high proportion of traffic accidents. Drivers need to adapt to the changes of the surrounding landscape especially when passing through tunnels. Coupled with the tunnel entrance and exit as well as the environment in the tunnel, drivers may easily experience visual and physical fatigue, which may in turn cause serious traffic accidents.

2.2. Linear factors

2.2.1. Plane linear elements

Plane linearity is the basic element of road linear composition and is mainly composed of three parts: straight line, circular curve, and gentle curve. Different linearity will have different influences on driving.

(1) Straight line

Straight lines are widely used in road design because they save route length. Furthermore, the design is convenient, and the construction is relatively simple. When a car is going in a linear motion, the force of the vehicle is simple, and the driver can easily control his or her vehicle. In contrast, drivers are more likely to experience driving fatigue with excessively long curves. A straight line that is too short between curves will make the curves incoherent, which will bring optical illusion to drivers and easily cause driving errors. In tunnel construction, a straight line can shorten the length of the tunnel, thus reducing the additional fatigue experienced by the driver in the tunnel.

(2) Flat curve

When a vehicle is running on a flat curve, a centrifugal force is produced by the vehicle, which would easily lead to skidding. As a result, the driver may operate erroneously, thus further leading to safety accidents. The angle and radius of the flat curve are two basic linear indexes that can affect traffic safety at the entrance of tunnels. In tunnel engineering design, the horizontal alignment with long straight lines can shorten the construction period and make the construction more convenient; however, in order to maintain the direction of the road, a flat curve tends to be inevitable at the entrance of tunnels. This has raised the safety risk at tunnel entrances and exits. According to statistics, 79.91% of traffic accidents at the entrance of tunnels occurred at a flat curve. Therefore, the issue of adjusting the flat curve at the tunnel entrance in order to reduce the risk of safety accidents is crucial.

2.2.2. Longitudinal curve elements

Longitudinal curve elements include longitudinal slope and vertical curve. Longitudinal curve elements have a significant impact on traffic safety. Going uphill, the speed of any vehicle will decrease; however, the rates at which the speed decreases vary for different models; thus, accidents are likely to occur. When a vehicle passes through a large, longitudinal slope, the continuous climbing will cause the temperature of the car to peak, overload the engine, *etc*., all of which are very dangerous. Going downhill, the speed of the vehicle is often fast. It is easy to lose control and run off the road. Continuously going downhill will lead to overheated brake pad and brake failure, resulting in traffic safety accidents [4]. In the tunnel area and the tunnel entrance and exit, hedging lanes and climbing lanes cannot be set up, thus intensifying the danger. Traffic accidents easily occur when tunnel slopes are large, coupled with the complex external conditions at tunnel entrances.

The smaller the slope at the entrance and exit of tunnels, the greater the traffic safety. In the actual design of tunnels, it is necessary to design a slope in consideration of the drainage demand. According to the highway tunnel design code, in order to meet the basic drainage requirements, its longitudinal slope should be greater than 0.3%. In a word, in order to prevent tunnel entrance safety accidents from occurring, the longitudinal slope at the tunnel entrance cannot be too large or too frequent.

2.3. Environmental factors

The environmental factors at the entrance and exit of expressway tunnels include weather, light, noise, and air quality. The different environments inside and outside the tunnel have an impact on traffic safety. The sudden change in the external environment, especially at the entrance of the tunnel, requires drivers to adjust and adapt quickly. This will undoubtedly distract the driver's concentration, which would in turn affect traffic safety.

2.3.1. Weather

Different weather conditions will have different adverse effects on highway pavement performance, driver's sight, vehicles, and so on, thus affecting traffic safety. According to statistics of highway safety accident in China, the proportion of accidents caused by bad weather is as high as 50%, of which the proportion of major traffic accidents is as high as 71% [5]. Extreme weather factors include rain, snow, fog, hail, and so on. Tunnels are mostly built in mountainous areas, which are prone to bad weather, especially rain and fog. **Table 1** lists the proportion of traffic accidents in different weather conditions at the entrances and exits of tunnels in a year:

Table 1. Proportion of traffic accidents at the entrances and exits of tunnels in different weather conditions

Weather conditions	Sunny	Cloudy	Rainy	Foggy	Snowy
Proportion	32.55%	23.75%	25.63%	15.32%	2.75%

According to statistical data, traffic accidents at tunnel entrances and exits caused by adverse weather conditions account for nearly 70%, among which the proportion of rainy weather is 49.38%. This may be attributed to the fact that rainy weather significantly affects road adhesion coefficient. In the case of sunny weather, the adhesion coefficient of dry asphalt pavement is about 0.75, while in a wet state, the adhesion coefficient decreases to about 0.45–0.6, while the variation range of the adhesion coefficient of concrete pavement is smaller [6]. At the exit, the humidity inside and outside the tunnel will be different due to weather factors, resulting in differences in road adhesion coefficient. When drivers pass through the entrance and exit of tunnels, such differences will easily lead to accidents. This phenomenon is most apparent on snowy days. The proportion of accidents caused by snow, as shown in the statistics, is relatively low. On the one hand, the data in **Table 1** are derived from the statistics of Shaanxi Province, where snowy days are infrequent; on the other hand, there is no fundamental circumstance for traffic accidents to occur since the highways are closed when there is heavy snow. In spite of this, the adverse impact of heavy snow on traffic safety should be paid attention to. In addition, cloudy and foggy days will reduce visibility and affect the driver's sight, thus increasing the risk of traffic accidents.

2.3.2. Sound and light

An important factor affecting traffic safety at the entrance and exit of tunnels is light. This is because lights have a direct impact on the driver's vision. When driving, drivers need to continuously perceive the environmental information around their vehicles via vision to make reasonable driving operations to maintain smooth and safe operations and ensure the safety of their vehicles. At the entrance of tunnels, both the "black hole effect" and the "white hole effect" are likely to occur due to the sudden changes from bright to dark and vice versa. As a result, drivers are unable to normally acquire and perceive external traffic information as easily due to visual interference, thus causing traffic accidents [7]. In addition, when noise is produced by vehicles in a tunnel, noise cannot be transmitted outward due to the enclosed nature of tunnels; thus, the noise will be repeatedly transmitted in the tunnel, which creates more noise. This will, in turn, interfere with the judgment and response ability of drivers and raise the possibility of traffic accidents [8].

3. Safety improvement measures for tunnel entrances and exits

Based on the causes of accidents as discussed above, several measures that can reduce the probability of traffic accidents at the entrance and exit of tunnels and ensure highway safety are proposed.

3.1. Traffic signs

By setting sound traffic signs at tunnel entrances and exits, drivers are guided in such a way to correct their driving operations, thus reducing the probability of accidents. The specific setting can be carried out in the following aspects: (1) place signs that indicate the tunnel's name and length as well as for turning on one's car lights [9] 100 m before the entrance; (2) set up "speed limit," "no overtaking," and "no parking" signs 200 m in front of the tunnel entrance to regulate drivers' driving behavior before entering the tunnel; (3) set up a "recommended speed" sign 1 km away from the combined "speed limit, no overtaking, no parking" sign before the entrance to remind drivers that they are about to enter the tunnel and should maintain a reasonable speed; (4) according to the speed limit of different expressways, design two "recommended speed" signs; they should be placed within 1 km of the "speed limit," "no overtaking," and "no parking" signs before the entrance; the interval between the two "recommended speed" signs should be 500 m; (5) remove the "speed limit," "no overtaking," and "no parking" signs within 1 km of the useless interference signs; (6) lift the "no overtaking" and "speed limit" signs at the exit of the tunnel 100 m away from the entrance.

Through a series of signs, drivers will be reminded to abide by traffic rules when driving through tunnels. Moreover, these signs will help enhance their awareness, increase their concentration and seriousness, and reduce their visual fatigue, thus reducing the safety risk at the entrance and exit of tunnels.

3.2. Traffic line marking

Vibration marking is a traffic marking line composed of a series of grooves or convex grooves set on both sides of the expressway [10]. When a vehicle deviates and drives on the marking line, the vibration marking and vehicle tires will generate sounds or noises due to friction to remind the driver that the vehicle has deviated from the lane and that the direction of the vehicle needs to be corrected immediately. In continuous downhill or curve sections, anti-skid lateral deceleration marks can be set before the slopes and curves to remind drivers to reduce their speed and control their vehicles in such a way that they are in the correct lane [11]. Several methods can be used to set the marking positions of tunnel entrances and exits.

(1) Within the range of 150 m before the tunnel entrance to 20 m inside the tunnel, and from 20 m before the tunnel exit to 100 m outside the tunnel, white hot melt reflective vibration solid lines can be laid on the edge line and dividing line of the lane, with a width of 20 cm and 15 cm at the edge line and the dividing line, respectively.

(2) Visual transition yellow zebra crossing (hot melt reflective vibration marking) can be set at the right hard shoulder within 120 m before the tunnel entrance and 50 m after the tunnel exit. The line width should be 45 cm, with an interval of 100 cm and an angle of 45° against the driving direction, and outer line width should be 20 cm with white vibration marking.

(3) Two-component yellow anti-slip pavement can be set at the tunnel entrance and exit, extending 20 m into the tunnel and 30 m out of the tunnel. Nine sets of two-component yellow horizontal anti-slip marking lines can be laid 50 m from the tunnel entrance [12].

3.3. Protruding road sign

In order to enhance drivers' driving line of sight in poor weather conditions, such as rain, snow, and fog, protruding road signs can be set up on the basis of matching the edge line and the dividing line of the lane. Specifically, it can be placed on the carriageway dividing line within 150 m before the tunnel entrance and 20 m in the tunnel, and 20 m before the tunnel exit and 100 m outside the tunnel, with a spacing of 10 m [13].

3.4. Strengthen the management of tunnel entrances and exits

Strict management can effectively improve the traffic safety at the entrance and exit of tunnels. Several measures can be adopted.

(1) Ensure regular road maintenance. Road signs, lines, guardrail, and other safety facilities should be inspected and maintained in a timely manner to ensure that they are functioning well.

(2) Strengthen the patrol and inspection of traffic violations at the entrance and exit of tunnels; strictly deal with illegal driving behaviors, such as random parking, speeding, and random lane change at the entrance and exit of tunnels; and maintain the basic driving norms at the tunnel entrance and exit.

(3) Make use of modern internet information technology to understand the traffic conditions at the tunnel entrance and exit in real time and release timely information to passing vehicles so as to realize real-time dynamic road information exchange and improve the basic service level of expressways.

4. Conclusion

Highway tunnel entrances have many safety problems, thus endangering road traffic safety. Through a careful analysis of the causes of safety accidents and the corresponding measures to prevent accidents, it is possible to reduce traffic safety risk at the entrance and exit of highway tunnels and provide a safe driving environment for drivers, both of which are conducive to the sustainable and healthy development of highway construction.

Disclosure statement

The author declares no conflict of interest.

References

[1] Ma ZL, Shao CF, Zhang SR, 2009, Characteristics of Traffic Accidents in Chinese Freeway Tunnels. Tunnelling and Underground Space Technology, 24(3): 350–355.

[2] Li L, 2015, Analysis and Improvement Measures of Traffic Safety at the Entrance and Exit of Expressway Tunnel, thesis, Chang'an University.

[3] Han XY, Shao Y, Yang SW, et al., 2020, Entropy-Based Effect Evaluation of Delineators in Tunnels on Drivers' Gaze Behavior. Entropy, 22(1): 113.

[4] Zhang H, Influence of Longitudinal Slope Rate on Traffic Safety of Long Highway Tunnel Based on Running Speed. Science Technology and Engineering, 20, 20(16): 6635–6639.

[5] Chen Y, 2007, Research on Prevention System of Road Traffic Safety Accidents Under Adverse Weather Conditions, thesis, Chongqing University.

[6] Shen A, 2002, Causes and Preventive Measures of Traffic Accidents in Tunnels. Road Traffic Management, 2002(09): 40–41.

[7] Bai Y, 2021, Study on Optimal Design of Traffic Safety Facilities in Expressway Tunnel. Shandong Transportation Science and Technology, 2021(3): 81.

[8] Zhao X, Fang R, Mao K, et al., 2010, Effectiveness Experiment of Sound Strategy for Driver Fatigue Based on Physiological Signals. Journal of Southwest Jiaotong University, 2010(03): 457–463.

[9] Jiang M, 2019, Study on the Utility Mechanism of Traffic Signs in Expressway Long Tunnel, thesis, Beijing University of Technology.

[10] JTG D82-2009, 2009, Specification for the Setting of Highway Traffic Signs and Markings, People's Communications Press, Beijing.

[11] Zhu S, Zhang Z, Wang H, 2013, Influence Mechanism of Pavement Edge Rate Marking on Deceleration Effect. China Safety Science Journal, 23(6): 110–115.

[12] Yuan P, 2020, Analysis of Problems and Improvement Measures of Safety Facilities at the Entrance and Exit of Tunnel in Lanhai Section of G6 Beijing-Tibet Expressway. Science and Technology Vision, 2020(15): 229–230.

[13] Industry Standard of the People's Republic of China, 2014, Code for Design of Highway Tunnels Volume II: Traffic Engineering and Ancillary Facilities, JTG D70/2-2014, People's Communications Press, Beijing.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 1
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Urban Plazas: The Politics of Space in Urban Constraints

Stefenie Lai*

Sydney School of Architecture, Design and Planning, The University of Sydney, Darlington NSW 2008, Australia

***Corresponding author:** Stefenie Lai, slai6207@uni.sydney.edu.au

Abstract: The most crucial notion in built environment studies, space, is forced to undergo a reinterpretation due to the influence of numerous social phenomena and cultural movements, such as postmodernism, the information age, and globalization. The traditional concept of time subverts time division and space restriction, along with the changes brought on by contemporary urbanization and postmodernist cultural norms. As a result, the urban plaza area, which is a unique cultural space, begins to take shape. It brings together previously different places, such as "public and private," "political and daily," "working and leisure," as well as "physical and virtual." The urban plaza is a useful research subject since it is a public area where the majority of cultural traits associated with urbanization are found. The spatial politics of the urban plaza experience a historic shift from macro politics to micro politics under the influence of postmodernism. Premised on this notion, the purpose of this study is to investigate the specific space of today's cities, which is the urban plaza, as well as the politics of space and the in-depth interpretation of space culture. This study uses techniques from many other fields that are related to spatial ideas, including philosophy, political science, cultural studies, and geography. This study expands the cultural space of post-modernist interpretation of cultural depth of character based on the theoretical paradigm in multidisciplinary cross-application in order to enhance individuals' awareness of urban plaza cultural forms and further their understanding of its political and cultural space power traits as well as underlying meaning. This paper examines the role and culture of urban plaza from the perspectives of numerous well-known spatial culture theories in the context of the analysis. In addition to identifying the nature of the cultural politics, this paper addresses the significance of spatial politics of urban plazas.

Keywords: Dystopian architecture; Spatial expense; Politics of space; Spatial governance

Online publication: January 17, 2023

1. Introduction

Individuals are turning to the impromptu "space" in prime areas, such as urban plazas, as a "substitute" for their search for nature in today's metropolis. Returning to the plaza is similar to returning to earth and to nature. We search for the sentiment of standing on earth and the habitat where human live freely from urban plazas. In the construction of contemporary urban space, the unique natural aesthetic landscape and open public space of urban plazas provide an important platform for urban life and heterogeneous urban residents who are far from nature to meet and interact. This not only helps to alleviate the contradiction and division between civilization and nature in urban space, but also provides a public bridge for urbanites to get out of their spiritual and psychological "pigeonholes" [1]. American architect Karsten Harries has once said, "Architecture has an ethical purpose in that it draws us out of the everyday banal, recalling the values that govern our existence as members of society; it summons us to a better, somewhat closer to the ideal life [2]." The city is an ensemble of buildings, the architecture is the primary body of the city, and the many volumes

and shapes of the city are significant parts of the city's personality [3]. Individuals have therefore discovered this "rewilded nature" in the public spaces of modern cities. We find "nature" in the city and enjoy our individual "solitude" and "freedom" there. Additionally, urban plazas have a carnival-like atmosphere in the urban lives of its inhabitants, bringing to life the joy of "heterotopic space" outside of everyday life and political space. Through this, individuals often feel relief from the difficult affairs of the world while they are at the urban plaza. The urban plaza thus becomes a place where individuals look for harmony with "nature" in the living spaces of contemporary urban inhabitants. The urban plaza has been transformed into the "earth" where people search for peace with "nature" in today's urban living environment. People tend to hide their identities, conceal their sexual orientation, downplay their social roles, put off worldly responsibilities, and luxuriate in nature when they are roaming freely and leisurely around the urban "wilderness" of urban plazas.

2. Heterotopic space: The spatial imagination of urban plaza

2.1. A space of utopia

In our daily lives and cultural concepts, we divide space into separate sections and assign cultural implications to each space. There are privileges and taboos specific to each space. For instance, private space (the bedroom) versus public space, political space (the parliament) versus commonplace space, religious space (the church) versus secular space for men and women, torture space (the torture chamber) versus free life, virtual space versus physical space, *etc*. The most fundamental means by which cultural power can impose behavioural discipline is through the division and segregation of spaces. Culture is continually functionalized and favoured during the construction process, which leads to the development of cultural taboos in certain settings. For instance, in Western religious culture, churches are sanctified; in institutional culture, castles and torture chambers are constrained; in spiritual culture, theatres and stages are constructed. This is how Michel Foucault interprets the significance of space in "Space, Knowledge and Power," "Space is the cornerstone of all public activity. Any right's operation is based on space [4]." "There are genuine places and real places that are intended to serve as societal institutions and the numerous practically realized utopias that make up a culture. These locations create sorts of places that are outside of all places although they are truly located by contesting and even inverting certain real places that are simultaneously shown. Given that they are so dissimilar from the numerous places they relate to or reflect, I shall refer to these places as 'heterotopic' [5]." Foucault asserts that this "heterotopic" zone serves two purposes: "Anomalies have the tendency to produce an illusionary space that plainly excludes all actual space and all actual locations where isolated human life exists. An abnormality like that is more surreal. A different, disordered space is produced by a different type of anisotropy. This anisotropy may be compensatory rather than illusory [5]." The former is comparable to a stage from a forbidden play, while the latter is similar to some colonies. In actuality, several cultural causes have split the immense cosmos of human life into various spaces. In addition to the partition of the world into national and ethnic zones, there are many more areas in our life, each serving a particular cultural purpose. For instance, due to the inherent cultural codes and unique cultural functions of certain regions, churches, plazas, brothels, gardens, torture grounds, theatres, colonies, cinemas, cemeteries, docks, and some forbidden places in primitive cultures, all of them form a certain status of cultural space and differ from other daily life spaces outside them.

According to Foucault, "We extend ourselves through the space in which we dwell. It is also a self-contained heterogeneous environment where our lives genuinely end, where our time and history occur, and where we are consumed and worn down [5]." In actuality, we look for the "I" and "we" spaces between one another and the location of "I," and in the overall relationships of these spaces, we discover the "space" of our existence and its significance. Our sense of security and belonging seems to be found in the existence of "home" and the occupancy of "place." In terms of industrial civilization's urban environment, "Freedom

and restraint coexist in the city. It offers a certain mode of behaviour, a certain manner of moving, and a certain paradigm of thought. It is the ultimate text that capital, law, and order have created and recreated. It is intended to achieve the most successful practise, that is, to ensure that the forces of capital, law, and order are present in all aspects of daily life. However, due to the complexity of its various control and discipline systems, as well as the cracks that exist between them, it is the most chaotic of all environments [6].” In fact, there is a zone for discipline and governance in a huge metropolitan spatial system, as well as a zone of release for the system as a whole. Forces that are related and unrelated to the system itself coexist as a conduit for the system’s own security. The city has multiple dualities; it is both a real location and a place of fantasy; it has both an official and a hidden culture; it is an intricate web of roads, residences, public structures, transportation networks, parks, and commercial establishments; it is also a mashup of attitudes, traditions, expectations, and hopes that are ingrained in our hearts as urban subjects. We discover that there are several cities within cities and that the urban “reality” is not singular [7]. Consequently, a city is composed of numerous spatial activities serving a variety of purposes. There are a few diverse spatial forces operating within the overall urban spatial system. The qualities of the aforementioned diverse area are present in urban plazas. Both the “perceived space” in the empirical world and the “planned and sanctioned space” as viewed by scientists, urban planners, and politicians are distinct from this “alien space,” which is a “liminal space” that is both built on and beyond these two spaces and one that transcends institutions, existing more as a disorganized spatial organization of social order. In his book “The Third Space,” Soja [8] described his journey to Los Angeles and other real and imagined places and proposed the idea of “third space,” which is a comparison between the first space (materiality) and the second space, by reviewing the spatial perspectives of Lefebvre, Foucault, and others (physical space). The idea of the “third space” is put out as both an integration of the first space (physical space) and the second space (social, cultural, everyday life, political, *etc*.), as well as a transcendence of both and a deconstruction and rebuilding of the two [9]. The urban plaza in the post-urban era creates a popularized culture of plaza revelry in the micropolitical sense of postmodernism’s decentering and de-authorization rather than being restricted to a functional distinction or behavioural reproduction of the plaza at a specific stage in history. This type of spatial culture has a de-authorization, de-classification, and de-identification transgressive cultural nature. The urban plaza can be used for meetings, performances, games, competitions, and knowledge sharing. In addition to arenas and gymnasiums taking up some of the plaza space, large-scale political demonstrations and carnivals can also be hosted there [10].

2.2. A space carnival of many languages

There is a free space outside of the system, a free imagination, freedom from roaming, freedom from exile, and freedom to stand out and observe the world outside of the metropolitan world. This transcendent space, which avoids all forms of spatial compartmentalisation, has consequently evolved into a field of unrestricted activities for the populace. It appears to have a subversive and disorderly spatial carnival meaning that sidesteps institutional rules and regulations as an urban space that is outside of the system. What sort of heterotopic space is the urban plaza, then? Also, what type of component of the urban ecosystem is it? The urban plaza can be characterized by the following characteristics: a place of frequent but guarded exchanges, dense but mixed, anonymous but transient, highly stimulating but with poor interactions among people, and a noisy but lonely vagrant state of mind, which is a deep sense of survival of individuals in the big city. It is a spatial attribute at the same time, with many voices and unrestricted conversations, devoid of hierarchy or identity. “An orgy is not a spectacle for people to watch; people are in it, and everyone is participating because the whole idea of an orgy is to involve everyone [11].” According to Bakhtin, this means that there is no stage in an orgy, that is, it does not distinguish between actors and audience. As a result, everyone is welcome to join in the free festivities that take place in the area. The

plaza and the surrounding streets serve as the primary platform for the carnival performance [11]. It is not a stage for a play. However, as a carnival in its broadest sense is international and inclusive, and since everyone must participate in close embrace, the only appropriate location is the plaza. The plaza is a universally recognised emblem. A symbolic meaning is added by the carnival plaza, the location of the carnival performance [10]. In the de-identified and non-hierarchical space of public contact, this type of plaza-like revelry and open discussion has given rise to a multi-voiced version of democratic politics that has an anti-monocentric ideology, and in turn a spatial political significance. In actuality, the "plaza" itself is a very political cultural area when it comes to the cultural analysis of the urban plaza. Agora is frequently the location of the government, but it is also where the majority of business, cultural, religious, and judicial activities take place. According to Ying Yu's article "Agora: The Revival of the Spirit of the Plaza," the Agora, which symbolizes an ideal of life aspiring to the values of freedom, equality, democracy, honour, profit, and sanctity [12], completely reflects the entirety of Western democratic society.

2.3. Free speech and political activity in the style of democratization

In specific settings, it offers a place to escape daily routines and let go of reasonable restraints, as well as a forum for unrestricted speech and unrepressed expression. The freedom of public uproar and public speech also gives room for the imagination to envisage defying societal norms and everyday conduct codes, such as escaping from hierarchical ranking and rational, disciplined behaviours. As a result, in addition to serving as a location for conventional political gatherings, the modern urban plaza also serves as a location for entertainment, free speech, and equitable discourse. The original site of political assembly has been replaced by a civic centre that serves a variety of purposes, including those related to culture and recreation. The urban plaza serves as a focal point for fully mobilizing public participation in both social and political affairs in the modern political concept of democracy and freedom. As such, it has the spatial potential to actualize the spirit of democracy, which is both an inevitable trend and a political potential of the plaza space itself. Individuals walking in this particular area are from various locations and have varying statuses, occupations, and levels of education. However, in this specific setting, they interact in an unidentified manner, that is, in a group activity. They avoid the privileges that society accords to a certain group or individual by greeting one another and establishing brief eye contact. As a result, within a certain context, "equality," "democracy," and "freedom" are created among them. They speak with a democratic-like freedom of speech and expression; there is no distinction in identity, difference in social rank or authority, or cultural antagonism of race or gender. As a result, the way that people live in this particular location is an expression of their culture and of democratic political life. In this disorderly realm of freedom, where social rights and laws are disorganized, individuals' freedom-related joy and desires, which the system have repressed, are allowed to run amok. It disregards the rules of society as a whole yet does not insult any particular person or group, invoking that "rules govern society, daily life, and the interpretations we make of it." They influence not only our conduct and judgement, but also the social categories that give the world its meaning. Categories are broken in orgy, just as brutally as people break the rules [13]. This "spatial game" of violating the laws of both space and individual's right to freedom is a game of defiance against the law, relishing the rush of fulfilling the need to breach the law. Therefore, the postmodern city, which is a spatial representation of cultural chaos blended with a jumble of styles, is gradually being recognized as a frequent trait. The terms "consumption" and "leisure" suggest activities in which people attempt to experience everything [14]. This is the distinctive cultural quality of modern metropolis, which is exemplified by the cultural syndrome of mixed styles, the juxtaposition of multipurpose spaces, and the freedom of transgressive revelry in the design and spatial organisation of urban plazas.

2.4. Spatial resistance to disorder

The spatial cultures of urban plazas are hence totally resistant. It is a roomy, creative setting. According to Gaston Bachelard, "Instead of living in a uniform and lifeless environment, we actually reside in one that is rich with characteristics and perhaps even illusions. Nature resides in the space we initially perceive, the space of our dreams, and the space of our passions [7]." The spatial "heterotopia" of urban plazas offers a way out of this dichotomy of spatial functions or more specifically a way out of social norms, developing into a heterotopic environment with a subversive or disrespect for authority. Considering that it re-creates a "third place" that is both beyond and outside the purview of a right to punishment, the "third space" is a place that is constantly open to possibilities, as American postmodern geographer Edward Soja describes in his book "The Third Space." The "new world" is built on the first space of experience or perception and the second space of ideology or utopia. It is not only a place of life and imagination, but also a "new world" of struggle toward new possibilities [12]. As a result, this space's dual nature, unusual nature, and counter-dual paradigm give it the qualities of a battlefield and a "public zone" that many people snobbishly invade or claim. It is revolutionary and rebellious due to its diverse "marginality" and "public sphere." Therefore, only an integrated study can observe, reflect on, and live in every area of the city [1]." This is the meaning of the "third space," as suggested by Edward Sawyer. The simplistic dichotomy between public and private spaces may preclude a deeper understanding of the characteristics of urban space.

This is what academics who are charged with achieving spiritual enlightenment are searching for. According to Nietzsche, "What we lack in our large cities are calm, open places for contemplation. There is a paucity of buildings and places that convey the magnificent sense of thought and of being outside [15]," when referring to how architecture impacts our spiritual space. He also expressed that modern cities' and their architecture's vocabulary is "too rhetorical and illiberal" [14]. "We, who do not believe in spirits and gods, are unable to think clearly in such a setting. As we move through these structures and gardens, we want to lift our feet up among our "selves" and witness ourselves change into wood and stone [15]." Baudelaire travelled the streets and plazas of Paris alone in the late hours of the night looking for a place of "otherness" to hold his spiritual solitude, like a "ghost" scavenging the waste of Western civilisation. Baudelaire appears to believe that his existence and modernity's "occasional and fleeting" mobility have temporarily ceased in the quiet and gloomy streets and alleys of Paris so that he could take a good look at this metropolis, which is the embodiment of modern civilization, and reflect on what has happened to modernity. What has happened to the existence of humans? Therefore, Baudelaire is not merely a "casual stroller [16]" or "wanderer," but rather a "ghost" beyond the system, as he ambles about the streets and plazas of Paris. These "ghosts" study the affluence and decadence that modernity has given to the city in the quiet night's darkness before using "stingers" that resemble scorpions to deeply inflict their curses on the rotting peach blossoms [17]. Intellectuals used this period as a "refuge" from the realities of their life and their passive circumstances, and in this heterotopic zone, they investigated both those who were a part of the system and the system itself. In order to live poetically in the contemporary urban environment, these lone wanderers looked for "earth" in the metropolis, while perpetually reflecting on human civilization and modernity. "We love the places we detest, we leave the places we love, and we go back to the places we love for the rest of our lives just to lose them," as Terence Davies states in his film "Time and the City" [18]. The study of urban space culture in the post-urban era has been further affected by this "return to the land" and the cultural tendency of reflecting on modernity. For instance, the postmodern social theory and democratic outlook of German philosopher Habermas are in and of themselves a conceptual critique of social institutions arising from the structural restructuring of the public sphere and spatial politics [19]. In addition, a number of academics, including Foucault, Lefebvre, Sawyer, and Crang [20-22], have concentrated on post-urban cultural space, creating a tendency known as the postmodernist spatial turn in cultural studies and the development of urban cultural studies.

3. Politics of collected space

3.1. Space-related festivities or consumption

"This is the direction of social control, which positions individuals and collectives in the coordinates of time, space, and existence. The category schema formed by accidental and passing social patterns give the world its order and the objects of the world their identity. Through their acts within that space and their comprehension of that space, civic subjects, as members of a particular society, learn about the space in which they are positioned and embrace their identity as citizens [1]." Individuals spend the majority of our time and energy in their daily lives consuming space both during the day and at night [22], immersing themselves in the joyous playground of daytime pleasures. Holiday resorts, public places, trade shows, supermarkets, amusement parks, malls, pubs, cabarets, *etc*. have all evolved into designated areas for people to unwind. People play around with the cultural connotations of these metropolitan settings and indulge in their own interpretations of what space means. They take pleasure in the contentment and comfort of the field in these particular venues for enjoyment in a symbolic reverie of democratic freedom and identity. They engage in unrestricted play and relaxation in this "disordered" setting that is governed by civilized order. Modern individuals who experience existential repression and the quick flow of modernisation need to balance, relax, let their bodies transcend, and let their minds rest; thus, in addition to a living space and material requirements, these spaces also cater to their spiritual solace and artistic pursuit. The urban leisure plaza, which is a community space that is full of warmth and laughter, is just one example of a location where individuals may unwind and enjoy themselves. They can completely unwind their typically uptight brains whether they choose to stroll or converse, congregate for enjoyment, or enjoy the festivities [23]. Even so, Bachkine has given an eternal cultural-philosophical significance to this temporary departure from the rational order, elevating it to the level of philosophical ontology, and thus called it a "new culture of human relations" based on the "culture of laughter" [24]. The cultural rebellion and postmodernist cultural politics of Bakhtin's "carnivalization" theory are, however, far more important than the theory's historical documentary significance. In fact, it could be argued that the former is more of a cultural imagination and political fiction of the present. The carnivalized nature of folk culture raises questions about its historical veracity [24]. Furthermore, according to folklore, a "carnival" is a semi-realistic, semi-performative folkloric event that generally disappears in a hurry. This is because people resume their normal, orderly everyday lives after a brief carnival [25].

3.2. Spatial catharsis and re-ordering

In the post-urban era, the urban plaza has almost entirely evolved into a place where people can uninhibitedly amuse themselves, unwind, and shop. However, the creation of urban space is frequently imposed by a certain ideology. Instead of being an ideal zone of freedom, the urban plaza is a public sphere that the state ideology has purposefully created. It is an area that is openly governed and secular. The presence of social power is a manifestation of the social and economic power of the city, although the plaza fosters a free spatial ecstasy and a democratized nature of life that subvert authority since it is independent of the power regulation system. Its omnipotence and pervasiveness, however, display the existence of social power. Consequently, authorities are continually watching over and controlling the diverse territory of the plaza. A "public realm" that the government purposefully chose for the public to be schooled, where the government exhibits its unshakeable governing stance, the plaza is itself a type of cultural discipline, from its establishment to the cultural symbols and spatial arrangements of the plaza. In the case of Piazza San Marco, on the one hand, the interface and layout of the space is a metaphor or manifestation of the Republic's ideals, making it the embodiment of the Venetian Republic's political, religious, and economic power, which, like the national flag, fosters a sense of identity and pride among its citizens; on the other hand, the distinctive environment the space creates will arouse various emotions in visitors. The plaza

appears to be merely a "stage" for festivals and processions, but in reality, it forms a whole with the processions and any activities that take place in them, strengthening the people's identity with the current social order and hierarchy of power by allowing them to observe or participate [26]. The area served as a hub for popular petitions, protests, and revolutions in its historical incarnation as well as the favoured location for the state authorities to assert their authority and carry out public disciplining. Naturally, the plaza's role as a site of public catharsis has diminished as a result of this power demonstration, and it is now more subtly acknowledged as such. The key method is the "non-repressed anti-sublimation" catharsis of desire, which keeps its approval of freedom and consent to celebration, even the expression of rebellion, within the bounds of control. They resume their identification with reality and system compliance after the catharsis. In this way, the plaza serves as the cultural system's vent, in which after emotions have been let out, the door is carefully shut. No culture can actually sustain its own constant waste, nor can it stand to have its body coated in the "abominable" excrement. As a result, the plaza evolves into a designated and predetermined location for the general population to enjoy themselves, creating a sense of independence and rebellious thrill. However, in the state of "disorder," the desire for destruction and subversion return to their old calm, the rushing waves return to the river valley, and the vanished "embankment" reappears on the horizon. This is an assessment of the "embankment" and a release of pent-up energy. The flood of lust and the "embankment" of civilization keep bumping against one other in search of a "proper" location. As a result, the plaza, the centre of the city, becomes a place for festivities, fairs, leisure, chanting, meetings, and discussions; for following the development of the city; and even for watching the prisoners on the gallows, thus becoming a microcosm and witness to the growth of civil society. All of these are genuine reflections of the urban plaza and daily life.

4. Conclusion: Diversified and juxtaposed flow space

In the 1950s and 1960s, as postmodernist culture and post-urbanization both grew, the traditional Western division between public and private spaces, with the former serving as a place for action, production, and political participation, and the latter serving as a place for consumption and reproduction, has come under intense scrutiny from theorists who contend that gender inequality and economic injustice are to blame for in this regional distinction [26]. However, the urban plaza's modern purpose gives it a transcending quality that goes beyond the dichotomous concept. The urban plaza dismantles the conventional theoretical binary partition of space in this way. The urban plaza is a site where several forces and voices are contrasted at the same time. A cultural battle over space is currently taking place between areas where public announcements are made by the government, areas where people can move freely, and areas where companies are located. A variety of forces, including governmental, commercial, popular, intellectual, and vagrant forces, occupy this public area. As a result, it attracts a large number of voices from people of different nationalities, areas, and cultures. These voices combine in the plaza to create a polyphonic thematic variation of many voices. A micropolitical influence of plaza politics is produced by the historical modification of the functions of the urban plaza in the post-urban era, which has also led to its transition to a stage of democratic life in modern society. It has spawned a wide range of new positions and equally vibrant new potentials, which have in turn led to corresponding modifications in the law, behaviour, morality, attire, architecture, *etc.* [26]. The urban plaza has evolved into a postmodern cultural space as evidenced by its ambivalence, ambiguity, and inconsistency, the breakdown of binary models, the obfuscation of boundaries and the complexity of the composition of the subjects of activity in the plaza, as well as the eclectic juxtaposition of domination, obedience, entertainment, revelry, and resistance. This has resulted in the adoption of a more postmodernist democratic politics by the plaza.

Disclosure statement

The author declares no conflict of interest.

References

[1] Liu S, 2008, Citizen Plaza and Urban Space Production. Gansu Social Science, 2008(3): 50–52.

[2] Harries K, 1998, The Ethical Function of Architecture, MIT Press, London, England.

[3] Shao Z, Cao R, Zai J, 2004, City-Culture-Architecture. Urban Issues, 2004(6): 8.

[4] Crampton JW, Elden S, (eds) 2012, Space, Knowledge and Power: Foucault and Geography, Ashgate Publishing, London, England.

[5] Foucault M, 2019, Texts/Contexts: Of Other Spaces, in Grasping the World, Routledge, London, England, 371–379.

[6] Fiske J, 2010, Understanding Popular Culture, 2nd Edition, Routledge, London, England.

[7] Chambers I, 2002, Popular Culture: The Metropolitan Experience, Routledge, London, England.

[8] Soja EW, 1998, Thirdspace: Journeys to Los Angeles and other Real-and-Imagined Places. Capital & Class, 22(1): 137–139.

[9] Fiske J, 1987, Television Culture, Law Book Co of Australasia, Pyrmont, Australia.

[10] Gardiner M, 2014, The Dialogics of Critique: M.M. Bakhtin and the Theory of Ideology, Routledge, London, England.

[11] Wang D, Niu Y, Lu L, et al., 2015, Tourism Spatial Organization of Historical Streets – A Postmodern Perspective: The Examples of Pingjiang Road and Shantang Street, Suzhou, China. Tourism Management, 48: 370–385.

[12] Yu Y, 2002, Agora: Rejuvenation of Square Spirit. Planner, 18(11): 93.

[13] Wirth JM, 2005, Nietzsche's Joy: On Laughter's Truth. Epoché: A Journal for the History of Philosophy, 10(1): 117–139.

[14] Ward G, 1993, Lyric Poets in the Era of Late Capitalism, in Statutes of Liberty, Palgrave Macmillan, London, 135–176.

[15] Dai L, 2010, We Fall in Love with the Place We Hate. Vision, 2010(2–3): 14–15.

[16] Habermas J, 1991, The Structural Transformation of the Public Sphere: An Inquiry Into a Category of Bourgeois Society, MIT Press, Massachusetts.

[17] Lefebvre H, 2012, From the Production of Space, in Theatre and Performance Design, Routledge, London, England, 81–84.

[18] Crang M, 2008, Cultural Geography, 2nd Edition, Routledge, London, England.

[19] Billingham CM, Kimelberg SM, 2013, Middle-Class Parents, Urban Schooling, and the Shift from Consumption to Production of Urban Space. Sociological Forum, 28(1): 85–108.

[20] Lachmann R, Eshelman R, Davis M, 1988, Bakhtin and Carnival: Culture as Counter-Culture. Cultural Critique, 1988(11): 115–152.

[21] Smilde D, 2004, Popular Publics: Street Protest and Plaza Preachers in Caracas. International Review of Social History, 49(S12): 179–195.

[22] Morton IJ, Johnson J, 2019, Planning for Hospitable Public Spaces and the Changing City: A Content Analysis of the City of Sunderland Unitary Development Plan. Hospitality & Society, 9(3): 267–290.

[23] Watson S, 2013, City Publics: The (Dis)Enchantments of Urban Encounters, Routledge, London,

England.

[24] Berney R, 2010, Learning from Bogotá: How Municipal Experts Transformed Public Space. Journal of Urban Design, 15(4): 539–558.

[25] Cavallaro D, 2001, Critical and Cultural Theory, Continuum International Publishing Group, London.

[26] Mumford L, 1998, The City in History: Its Origins, Its Transformations, and Its Prospects, Fine Communications, New York.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 1
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Discussion on Optimization Measures of Building Construction Management Technology

Chaomin Huang*

Jilin Engineering Normal University, Changchun 130052, Jilin Province, China

***Corresponding author:** Chaomin Huang, 395665217@qq.com

Abstract: Building construction needs have expanded in line with people's demands and the quality of life in today's society. Therefore, the traditional construction management technology can no longer meet the current management and construction requirements, so it is necessary to further optimize the construction management technology. Therefore, this paper focuses on exploring measures regarding building construction technology optimization. Firstly, the paper briefly expounds its optimization value, then systematically analyzes some problems faced by the current housing construction management, and finally puts forward some targeted management optimization measures for future reference.

Keywords: Building construction; Construction management; Technology; Optimization

Online publication: January 17, 2023

1. Introduction

With the acceleration of urbanization construction, the scale and speed of housing construction are constantly on the rise. People are paying more attention to the construction work and are putting forward new requirements for its development, which leads to the mismatch between the construction management technology and management objectives of housing construction, affecting the overall construction management. In this regard, measures need to be taken according to the specific situation and the problems faced, so as to improve the technical level of construction management and ensure the quality of construction management of the housing project, all of these which will be further discussed in this paper.

2. The importance of optimizing building construction management technology

The technology of housing construction is constantly evolving along with the development planning of the city, the project management concept of housing construction engineering, and the construction technology, which means that innovation and optimization are very important for the construction industry. The importance of optimizing building construction management technology can be embodied in the following two aspects:

On one hand, it is beneficial to establish a good work foundation. During the key construction of housing construction and civil engineering, construction management and construction safety management need to be carried out according to the actual construction situation and explore the construction management technology based on the overall requirements of project construction. It is necessary to accurately use the construction technology for different construction projects and phases, reasonably utilize construction technology, and then tamp the construction foundation, lay the foundation for the smooth progress of the project, reduce the hidden dangers of construction, and improve the quality of construction

specification management [1].

On the other hand, it is conducive to the innovation of housing construction management technology. According to our experience in building construction, in this paper, we will summarize the problems faced by the construction, and establish a sound construction organization management system with quality, safety, technology and cost management as the center, which is conducive to guiding the construction personnel to establish a high sense of responsibility, achieve fine control, and then improve the efficiency and quality of the construction management. In this way, not only can the hidden dangers in construction can be reduced, but the construction efficiency can also be improved, and the competitiveness of the construction sector can also be enhanced.

3. Problems faced by housing construction management

3.1. The management system is imperfect

The construction management of housing construction projects optimizes the utilization of construction technology according to the characteristics of engineering projects, provides guidance for the management of housing construction projects, and helps establish the construction foundation in combination with the national and industrial requirements as well as the relevant norms and systems of standardized construction [2]. However, in the actual construction of housing construction projects, the construction department does not pay attention to the system construction and national policies. Besides, the actual characteristics of the project the management and control of housing construction projects are not considered. The same construction management system is used for different projects without considering the characteristics and needs of each project. Besides, the system is lacking, the construction foundation standards, norms, control measures are not strict enough, which affects the standard of construction management.

3.2. Lack of refined control

Building construction involves many phases and management contents. For example, the construction requirements of quality, schedule and safety are different for different projects, so the construction personnel should carry out fine control according to the project type, so as to improve the comprehensive efficiency of the construction process. At present, the quality of construction personnel needs to be further improved. They generally lack the knowledge of fine management, and the strict control of material procurement, without integrating the management concepts of quality, safety, and budget. Therefore, in the construction process, various factors are not considered in the perspective of fine management, and prevention and control measures are not formulated. Moreover, and quality management of materials, machinery, society and other aspects is not carried out according to the actual situation [3]. During the engineering design phase, the specific construction situation and site environment were not fully considered when setting the budget, nor was comprehensive analysis work carried out in advance to improve the bidding management, which led to problems in the project and affected the implementation of project design standards. In addition, there is lack of professionalism among workers, the investment for talent management is insufficient. In turn, the quality of the overall staff is lacking, and they do not have much sense of responsibility, hence affecting the quality and progress of the project. At the same time, there will also be more safety risks during construction without well-qualified staff and proper safety awareness. Lastly, the construction technology management has not carried out fine management according to the actual situation; the schedule, quality and safety management links are not balanced, the construction management technology applied by the construction personnel is relatively simplistic, lack of innovation and flexibility, affecting the overall effect of construction.

3.3. Poor dissipation of information

It is necessary to carry out information management according to the actual project in the process of carrying out housing construction projects. However, the information management technology is not strictly implemented in the current construction, the relevant information collection is not timely and comprehensive, nor targeted analysis is carried out. The established project model does not fully reflect the characteristics of construction, and information real-time cannot be dissipated in time, causing inconsistencies among workers. As a result, scientific decisions cannot be made, which affects the construction effect and is not conducive to the implementation of the project [4].

4. Optimization measures of building construction management technology

4.1. Improving the management system

A suitable management standard and system is established according to the construction characteristics of housing construction project. In the management of project, no matter how innovative construction technology is, corresponding support management should be established to ensure smooth construction. Therefore, it is necessary to clarify the project construction requirements, organizational management objectives, management and control standards, and construction methods when establishing the management system. Besides, it is necessary to guide the construction personnel to analyze the relevant policies according to the actual situation of the project, and strictly implement the construction system. The management department should also pay attention to the changing trend of the market, improve the construction management standards according to the requirements of policies and regulations, and ensure that the construction quality of construction projects meets the standards [5], as shown in **Figure 1**.

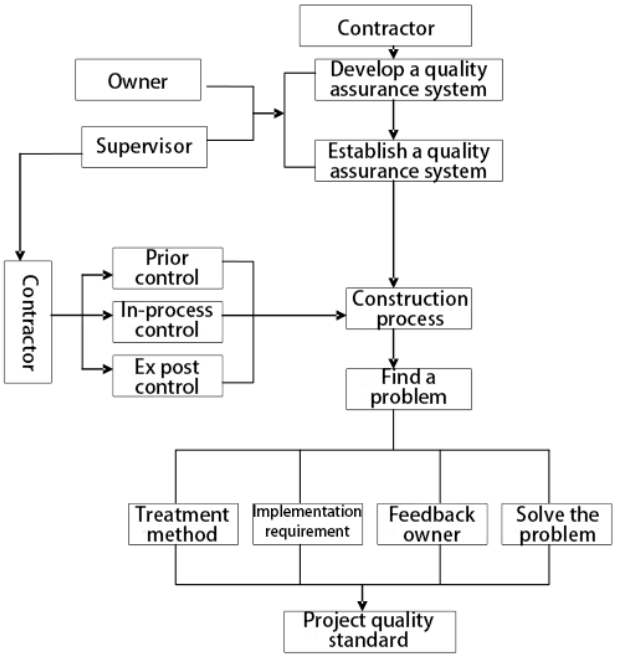


Figure 1. Project construction management process

4.2. Strengthen refined management and control

During the construction of housing construction projects, it is necessary to establish a refined management concept, establish a comprehensive management system focusing on progress, safety, quality, cost, and so on, and strengthen process supervision to ensure that the project can be carried out according to standards. For this, the construction personnel need to scientifically analyze the overall construction goals, establish and improve the bidding management mechanism in the design phase, and select high-quality suppliers.

Before the construction of the project, the construction design needs to be fully certified, the construction site environment and original data should be comprehensively analyzed, and various elements of the construction process should be analyzed, calculated, and studied based on the corresponding data model, so as to formulate a complete design scheme and organization scheme. During the construction, it is necessary to control the cost, strengthen budget management of materials, equipment and personnel at various stages, such as preconstruction, construction, and completion. Moreover, the budget implementation needs to be quantitatively evaluated, make it meet the requirements of the design drawings, optimize the allocation of various resources, and prevent wastage [6]. The management of materials, cost, progress, quality, and safety shall meet the requirements described below.

4.2.1. Material management

In housing construction, good material management can help save construction costs and improve construction quality, which is also the main purpose of construction management technology. At present, in the process of material management of housing construction engineering, in order to obtain benefits, some material manufacturers cut corners, resulting in inconsistent material quality. In fact, some purchasing personnel deliberately buy substandard materials for their own interests, falsifying prices, resulting in material problems, affecting the quality of construction, which are prone to cause engineering accidents. This poses serious safety risks when the building is in use. In this regard, in order to improve the management quality of building construction materials, first of all, it is necessary to control the purchase price of materials, strictly prohibit the phenomenon of shoddy work and shoddy work in the construction process, strengthen the management of raw material purchase process, formulate a scientific purchase plan, purchase the required raw materials according to the plan, ensure that the materials meet the construction quality requirements as far as possible, and reduce the construction cost [7]. Secondly, the performance of materials shall be tested. During procurement, the procurement personnel shall carefully check the quality certificate and warranty of the purchasing manufacturer and test the quality of construction materials to ensure that they are up to standard. For example, the surface of reinforcement shall be cleaned before construction, and its deviation shall be controlled. The allowable deviation is shown in **Table 1**. It is necessary to improve the quality of materials required for construction and avoid using of subpar products. Finally, it is necessary to strengthen the management of material use, pay attention to material management in the process of housing construction, ensure that the material use method and quantity meet the requirements, and improve the construction quality. The construction unit needs to set up a warehouse for storing materials separately on the site, so that the performance and appearance of materials will not change, mix the materials using proper methods, and carefully inspect the construction equipment and machinery regularly.

Table 1. Allowable deviation range of steel bar processing

Deviation item	Allowable deviation range (mm)
Length of stress reinforcement and anchor bars	± 10
Length of parts	± 5
Starting point of steel bar bend	± 2
Steel bar turning	± 3

4.2.2. Cost management

In the process of building construction management, cost management is one of the key and difficult components. Appropriate cost management can effectively use construction funds, reduce construction

costs, and make construction activities go smoothly. Therefore, in order to optimize the cost management technology, it is necessary to first strengthen the cost management before construction, define the construction contract, then sign the corresponding contract according to the bidding documents. The terms and conditions of the construction should be clearly reflected in the contract in detail to ensure that the they are reasonable and favorable. After determining the cost, it is necessary to establish and improve the assessment system and accountability mechanism and take effective measures to control the construction cost [8]. Secondly, it is necessary to optimize the budget plan, ensure that the budget plan is scientific, and avoid affecting the construction management quality and project cost level. For this, it is necessary to comprehensively investigate the situation of the whole construction project while preparing the construction budget, and comprehensively analyze the situation of the construction site and the construction organization. At the same time, it is also necessary to carefully study the construction drawings, and then prepare the construction budget, and combine the construction site and manual drawings to make the budget preparation more scientific and reasonable. Lastly, it is necessary to pay attention to the cost management at the completion stage. There are many risk factors in a housing construction. If a safety accident occurs, it may delay the construction period, cause casualties, and thus increase the project cost. In view of this, the management of construction safety needs to be strengthened, relevant personnel should be allocated for safety management, and prevent construction accidents altogether. At the same time, all kinds of data should be strictly reviewed after the construction is completed, so as to prevent cost increase caused by accident omission.

4.2.3. Progress management

The construction progress management technology is also an important part in construction management. Through scientific control of the construction progress, the construction project can be completed on time, various resources can be optimally allocated, and the construction cost can be reduced. In order to optimize the construction schedule management technology, we a scientific construction schedule should first be prepared. The construction process should be planned according to the construction scheme while fully considering the influencing factors and the contract provisions. When formulating the construction plan, we should pay attention to the preparation of components that are difficult to construct and ensure their qualities as much as possible. We also need to pay attention to the effective application of construction materials and equipment. Secondly, to manage the construction progress, the construction personnel need to conduct a comprehensive and systematic analysis of the construction characteristics of the housing construction project, identify the problems that might occur during the construction and the factors affecting the progress, and also strictly monitor the compliance with the construction schedule to effectively control the construction process. In this regard, the construction unit needs to build a high-quality construction progress management team, rely on professionals to solve the problems that may occur during construction, standardize the construction management methods, effectively standardize the construction activities, and guide the orderly implementation the activities according to the schedule. At the same time, the construction unit also needs to improve the level of the housing construction scheme and join forces with the supervision unit to strictly analyze the feasibility, scientificity, and rationality of the design, and put forward appropriate modifications if necessary, so that the construction can be completed on time, and prevent project delay.

4.2.4. Quality management

In the new era, in order to meet the new requirements for housing construction, the construction unit needs to pay attention to quality management. In order to optimize the construction quality management technology, it is necessary to establish and improve the quality management mechanism, in which the standards of construction accident report, problem accountability, quality control, and so on are clearly

formulated. Relevant personnel need to be assigned for different tasks, so as to timely deal with the engineering quality problems that may occur in the construction, ensure that the construction problems are effectively controlled, and ensure the economic benefits of the project. At the same time, it is also necessary to allocate supervisors to actively carry out quality warranty, project inspection, production and construction, material procurement, construction preparation, and other related work, so as to optimize the construction quality. Secondly, it is necessary to optimize the construction method. In building construction quality management, it is necessary to ensure that the construction technology and scheme are scientific and advanced. In order to manage the construction quality, the construction personnel need to carry out scientific construction according to the relevant requirements of construction standards, procedures and schemes. However, although the use of modern technology can improve the construction efficiency and quality, it will lead to an increase in construction costs. Therefore, managers need to analyze various economic factors, and select appropriate construction processes and methods in combination with the characteristics of the project, so that the construction quality can meet the standard requirements, thereby reducing costs. Finally, the key components of quality management should be clearly defined. In order to prevent the construction progress from being affected, causing delays, resulting in project default, the key points of quality control for each sub project should be clarified. For example, the key points of quality control for reinforcement construction are shown in **Table 2**.

Table 2. Key points of quality control

Sub-project	Components of quality control
Reinforcement	Connect quality and order
Concrete	Concrete label, forming quality and maintenance
	construction of beam-column joint
Welding	Weld joint
Bolted connection	Torque assurance

4.2.5. Security management

The safety management in the construction process needs to reduce safety risks faced by the construction according to the safety guarantee goals of the "national livelihood project," construct an ideal safety risk level control system, ensure the scientific allocation of safety protection facilities, and then improve the construction safety awareness and safety skills, so as to make the construction project orderly.

4.2.6. Personnel management

Usually, migrant workers account for a large proportion in a construction team. The quality of their work is rather inconsistent compared to those of local technicians, and there is deviation in the implementation of construction technical requirements and specifications. The quality of personnel leads to problems in construction management. Therefore, proper technical training needs to be provided for construction management personnel, strengthen construction technical disclosure, and strengthen training for key post construction personnel, so as to ensure professionalism in thinking and technical skills.

4.2.7. Advancing IT management and control

During the construction of housing construction projects, innovative construction concepts and methods are implemented, and more efforts are made to build informatization. The construction management system shall carry out comprehensive information management and control around technology and management according to the specific requirements of the project construction, build project management software and

digital models through modern Internet and information technology, simulate and analyze the overall situation of the project design, and timely use information software to collect various information involved in the construction process. At the same time, comprehensive information applications should be created to identify all kinds of hidden dangers and optimize the construction plan after comparative analysis. In addition, the management department will also need to consider the ecological and environmental aspects in the development of new materials and new technologies, establish and improve the innovation management system, guide the construction personnel to innovate the construction process according to the actual situation, summarize the construction experience, constantly optimize the construction technology and process, integrate the ecological energy conservation and environmental protection concept into it, and improve the overall effect of the project construction. In addition, the information platform can be used to supervise and detect all segments of the construction, and subsequent construction can only be carried out after each segments passes the inspection. The management personnel can ensure the construction progress and attendance, find construction problems in a timely manner, and make corrections. The problems in construction should be recorded and summarized to avoid repeated occurrence of the same problem and reduce the incidence of problems. Besides, building information modeling (BIM) and other technologies are used to understand the key monitoring points of the project, solve the fault collision points, attach importance to the feedback of personnel, and timely solve the problems in the feedback.

5. Conclusion

In short, the scientific and rational application of management technology during the construction of housing construction projects affects the construction cost, construction progress and construction quality. In this regard, the construction unit needs to comprehensively analyze the influencing factors of construction management technology, and then select appropriate management technology. This paper proposes optimization measures such as improving the management system, strengthening refined management and control, and promoting information management and control, to control the construction progress, improving manual efficiency, ensuring project quality, reducing project costs, providing a good construction environment, optimizing the economic and social benefits of the housing construction unit, and promoting the sustainable development of housing construction.

Disclosure statement

The author declares no conflict of interest.

References

[1] Chen P, Fang X, 2022, Analysis of Building Construction Technology and Site Construction Management. Architecture and Decoration, 2022(9): 62–63.

[2] Guo T, 2022, Green Construction Technology and Site Construction Management of Building Engineering. Development Orientation of Building Materials (Part 2), 20(9): 168–170.

[3] Xu P, 2022, Analysis on Key points of Construction Technology Management of High-Rise Building. Building Materials and Decoration, 18(13): 81–83.

[4] Lu K, Tao Y, 2022, Research on Waterproof Construction Technology of Building Roof. China High-Tech, 2022(2): 89–90.

[5] Yu S, 2021, Management Measures of Energy Saving Technology in Housing Engineering. International Public Relations, 2021(14): 87–88.

[6] Zhang Y, 2020, Discussion on Construction Management of Civil Engineering Building. Regional

Governance, 2020(42): 179.

[7] Zhao J, 2020, Research on Building Construction Technology and Quality Control. China Management Information Technology, 23(16):132–133.

[8] Chen Y, 2020, Building Construction Supervision Site Quality Management. Commercial Observation, 2020(27): 60–61.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 1
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Carbon Footprint Analysis of Buildings Based on LCA Theory Under Carbon Neutrality Goals: Taking the 3rd China International Solar Decathlon Competition as an Example

Zeyu Yang*, Zao Li, Yitian Wang

School of Architecture and Art, Hefei University of Technology, Hefei 230009, Anhui Province, China

***Corresponding author:** Zeyu Yang, 2020171243@mail.hfut.edu.cn

Abstract: This paper focuses on the design of residential buildings oriented to the efficient use of solar energy, and selects the entries HUI HOUSE of Hefei University of Technology and Lille I University of France in the 3rd China International Solar Decathlon China Competition, based on the theory of the life cycle assessment (LCA) of buildings, and analyzes the carbon footprint from four aspects: building materials production and transportation stage, building construction stage, building operation stage, and building demolition stage. Through the calculation of the carbon footprint of buildings, the socio-economic benefits of HUI HOUSE in carbon reduction were analyzed; the result of the calculation was that HUI HOUSE achieved carbon neutrality in the ninth year, and continued carbon reduction after that, contributing a cumulative total of 947.54 tons of carbon negative in the life cycle of buildings.

Keywords: Zero-energy buildings; Carbon emissions from buildings; Carbon neutrality in buildings; Solar Decathlon

Online publication: January 17, 2023

1. Introduction

Since the 70s of the 20th century, the problem of global warming has been gradually highlighted. According to relevant statistics, as of 2017, the global average temperature has increased by 0.8 compared to the industrial age. Studies have shown that rising global temperatures can lead to rising sea levels, shrinking snowpack, and uneven global rainfall. The Paris Agreement proposes that the global average temperature increase should be limited to 2°C this century and strives to limit the temperature increase to 1.5°C above pre-industrial levels [1-6].

A Solar Decathlon (SD) competition was initiated and sponsored by the US Department of Energy, with universities around the world as the participating units of the solar building technology competition, the competition involves solar energy, energy conservation and building design, and is a forward-looking competition to maximize the use of renewable resources. This paper uses the life cycle assessment (LCA) model to analyze the carbon footprint of the project from four aspects: building materials production and transportation, building construction stage, building operation stage, and building demolition stage according to the 3rd China International Solar Decathlon Competition HUI HOUSE [7,8].

2. Introduction to carbon footprint calculation models

2.1. Building life cycle and carbon footprint theory

The concept of carbon footprint originates from the "ecological footprint," which refers to the total amount of gases emitted in human production and consumption activities related to climate change, which can be expressed in carbon dioxide equivalent (CO_2e) [9].

LCA-based building carbon footprint refers to the entire life cycle of the building, taking into account the entire input-output chain, in which the system boundary is determined by the CO_2 emitted through material and energy consumption. The building carbon footprint can be divided into 4 stages: building materials preparation, construction, building operation, and building demolition.

2.1.1. Production and transportation stages of building materials

The carbon emissions in the production and transportation stage of building materials shall be the sum of the carbon emissions of the production stage of building materials and the carbon emissions of the transportation stage of building materials, and shall be calculated according to the following formula:

$$\boldsymbol{Cjc} = \boldsymbol{Csc} + \boldsymbol{Cys}$$

where $\boldsymbol{Cjc}$ is the carbon emissions from the production and transportation of building materials (tCO_2e), $\boldsymbol{Csc}$ is the carbon emissions (tCO_2e) from the production stage of building materials, and $\boldsymbol{Cys}$ is the carbon emissions from the transportation phase of building materials (tCO_2e).

2.1.2. Building construction phase

To simplify the calculation of the construction phase of the building, this paper focuses on calculating the number of mechanical equipment shifts used in the construction stage, and uses this data to calculate carbon emission. The calculation formula is as follows:

$$\boldsymbol{Cjz} = \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} \boldsymbol{Q_{jz,i}} \times \boldsymbol{K_{jz,i}}$$

$$\boldsymbol{K_{jz,i}} = \sum_{\boldsymbol{i=1}}^{\boldsymbol{n}} \boldsymbol{T_{i,j}} \times \boldsymbol{F_{i,j}} \times \boldsymbol{Rz}$$

where $\boldsymbol{Q_{jz,i}}$ is the *i*th project quantity in the sub-project; $\boldsymbol{K_{jz,i}}$ is the energy consumption coefficient of the *i*th project in the sub-project; $\boldsymbol{T_{i,j}}$ is the *i*th project unit engineering quantity and the *j*th type of construction machinery shift consumption; $\boldsymbol{F_{i,j}}$ is the energy consumption of the *J* construction machinery unit shift of the *i*th project, the selection value is referred to the following table; $\boldsymbol{Rz}$ is the carbon emission coefficient of energy consumed by the *j*th type of construction machinery per shift.

2.1.3. Building operation phase

The calculation of carbon emissions in the operation stage of the building should include the carbon emissions during the operation of air conditioning equipment, domestic water, lighting equipment, and building carbon sink system in the operation stage. The lighting system is determined according to the needs of the builder and is powered by battery. The water system is mainly used for domestic and firefighting, which is tap water. Greenhouse gas emissions from refrigerant use in the heating, ventilation, and air conditioning (HVAC) systems are calculated as follows:

$$Cr = mr \cdot GWPr/1000$$

where Cr is the carbon emissions produced by refrigerants (tCO2); r is the type of refrigerant; mr is the refrigerant charge of the equipment (kg/unit); $GWPr$ is the global warming potential of the refrigerant r.

2.1.4. Building demolition phase

The carbon emissions of the building demolition stage are the carbon emissions generated by the use of various energy consumed by the machinery and equipment used in mechanical demolition, but because there is no data related to the energy consumption of the building demolition stage, the empirical formula method is selected to estimate the carbon emissions of demolition per unit building area. The formula is sourced from the "Guangdong Provincial Department of Housing and Urban-Rural Development Carbon Emission Calculation Guidelines," which is as follows:

$$\boldsymbol{Y} = 0.06\boldsymbol{X} + 2.01$$

where $\boldsymbol{Y}$ is carbon emissions per unit area ($kgCO_2/m^2$); $\boldsymbol{X}$ is the number of above-ground layers; It is calculated that $\boldsymbol{Y} = 2.13$ $kgCO_2/m^2$.

3. Project overview

3.1. Natural conditions of the site

The venue is located in Desheng Village, Zhangbei County, Zhangjiakou City, Desheng Village is 12 kilometers away from Zhangbei County Government, surrounded by large-scale hotels, homestays, inns, catering facilities and other complete facilities, convenient transportation. The overall land use shall be limited to conditional construction areas, and the site shall not occupy basic farmland. The layout of the building's surroundings is shown in **Figure 1**.

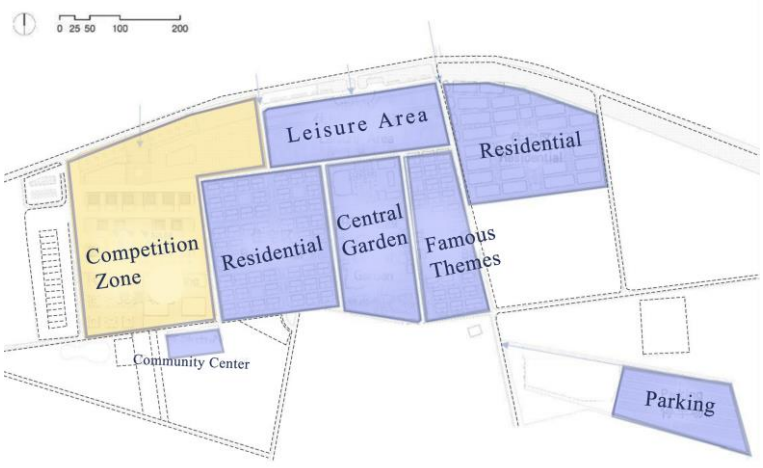


Figure 1. Facilities around the project site

3.2. Main meteorological elements

The project is located in Zhangjiakou City, Hebei Province. Zhangjiakou is located in the cold A zone and has a temperate continental monsoon climate. The four seasons are distinct, with dry and windy springs, hot and short precipitation in summer, sunny autumns with moderate temperatures, and cold and long

winters. The annual average temperature is 9 °C, the annual average maximum temperature is 15 °C, and the annual average minimum temperature is 3 °C. The rain and heat are the same season, and the growing season is cool. High temperature, high humidity, and few hot weather. The annual precipitation is 330–400 mm.

3.3. Building parameters

Team HUI, a team from Hefei University of Technology, representing Anhui Province in the decathlon competition, tried to integrate the architectural style of the Hui-style into the design of solar architecture. The traditional Hui-style architecture reflects a harmonious, orderly, and elegant architectural image, and the beautiful landscape where the architectural image and the mountains and rivers intersect each other, showing a unique regional style. The design is based on traditional Hui-style houses, blending modern construction systems and solar energy technology, and strives to explore the possibilities of new Hui-style houses. Due to the extensive integration of green energy-saving technology and building design, HUI HOUSE won the Silver Award for Energy Performance and the Sustainability Award in the Decathlon. The analysis of the architectural design concept is shown in **Figure 2**.

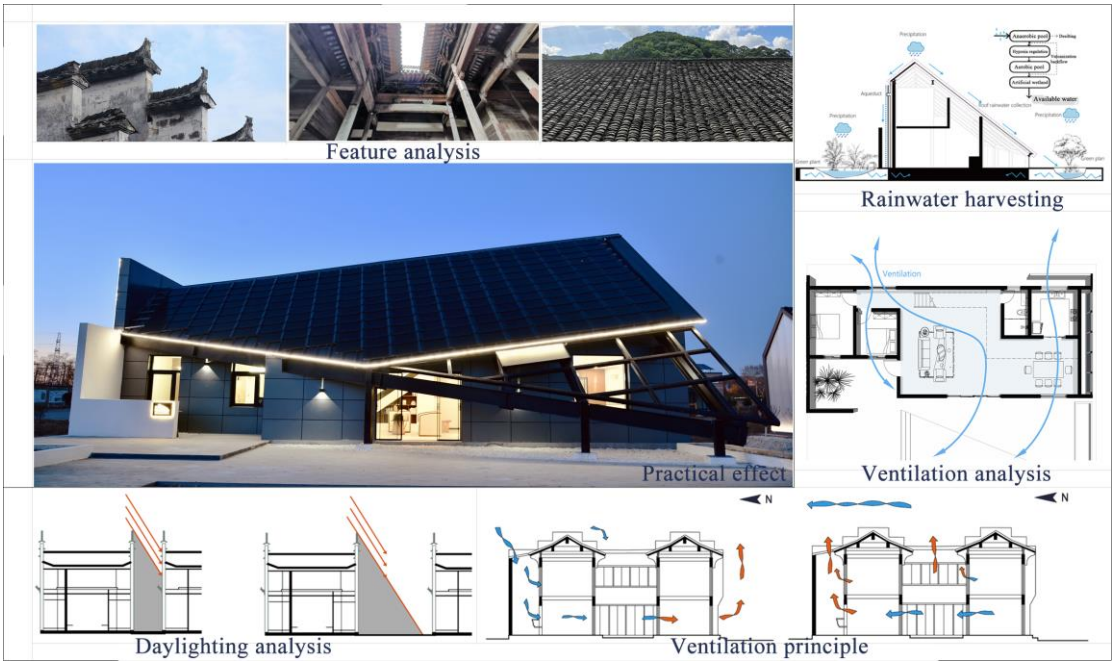


Figure 2. Architectural design concept

4. Analysis of accounting results

4.1. Calculation instructions

This report takes GB/T 51366-2019 and JGJ/T 449-2018 as reference to calculate the carbon emissions of the whole life cycle of building materials (production, transportation, and recycling), construction, operation, and demolition, and considers the optimization calculation of carbon saving, carbon reduction, and carbon neutrality control measures such as renewable energy and green vegetation (carbon sink) [10,11].

4.2. Calculation results of carbon emissions during the production and transportation of building materials

Carbon emissions of building material production stage is the carbon emitted by the building materials required during its production stage, and the calculation results are shown in **Table 1**.

Table 1. Carbon emissions from the production of building materials

	Types of building materials	Dosage	Unit	Production factor (tCO_2e/unit dosage).	Carbon emissions (tCO_2e)
1	Rebar	5.76	t	2.34	13.48
2	Concrete	60.48	m^3	2.95×10^-1	17.84
3	Glass	3.75	t	2.84	10.65
4	Thermal insulation rock wool	3.20	t	1.98	6.34
5	Color steel tiles	2.22	t	2.53	5.62
6	Roof panels	0.62	t	2.03×10^1	12.65
7	Steel	5.76	t	2.35	13.54
8	Exterior wall insulation panels	10.60	m^3	2.27×10^-2	0.24
9	PV modules	12420	W	1.41×10^-3	17.5
Total					**97.86**

The carbon emissions during the transportation stage of building materials are calculated by recording the means of transportation used in the construction process, and the calculation results are shown in **Table 2**.

Table 2. Carbon emissions generated during the transportation phase

	Types of building materials	Dosage	Unit	Mode of transportation	Transportation factor [tCO_2e/(t*km)]	Transportation distance (km)	Carbon emissions (tCO_2e)
1	Rebar	5.76	t	Medium diesel trucking (8t)	1.79×10^{-4}	1084	1.12
2	Concrete	60.48	m^3	Medium diesel trucking (8t)	1.79×10^{-4}		30.51
3	Glass	3.75	t	Medium diesel trucking (8t)	1.79×10^{-4}		0.73
4	Thermal insulation rock wool	3.20	t	Medium diesel trucking (8t)	1.79×10^{-4}		0.62
5	Color steel tiles	2.22	t	Light diesel truck transportation (load 2t)	2.86×10^{-4}		0.69
6	Roof panels	0.62	t	Light gasoline truck transportation (load 2t)	3.34×10^{-4}		0.23
7	Steel	5.76	t	Medium-duty gasoline trucks (8 tons)	1.15×10^{-4}		0.72
8	Exterior wall insulation panels	10.60	m^3	Light gasoline truck transportation (load 2t)	3.34×10^{-4}		0.08
9	PV modules	1.3	t	Light diesel truck transportation (load 2t)	2.86×10^{-4}		0.69
Total							**35.39**

4.3. Building construction phase

There are many details involved in the construction stage of this project, such as the list of project cost budget and final accounts, the main mechanical schedule, the actual construction record, and so on. The details of carbon emissions during the construction phase are shown in **Table 3**.

Table 3. Detailed information on carbon emissions during the construction phase

Project name	Construction machinery name	Energy consumption per unit	Energy usage units	Total shift consumption of construction machinery (shift)	Total carbon emissions (tCO_{2e})
New sub-project project	Forklift crane	26.46	kg diesel/shift	1.50	42.31
	Jack-up tower crane	166.29	kg diesel/shift	81.00	
	Crawler type single bucket hydraulic excavator	33.68	kg diesel/shift	2.00	
	Scroll type concrete mixer	34.10	kg diesel/shift	0.38	
	Concrete pump	243.46	kg diesel/shift	0.25	

4.4. Calculation results of carbon emissions during the operation phase of the building

In terms of design, HUI HOUSE used the area of the roof to achieve the integration of energy output, and the solar photovoltaic tiles were closely combined with the roof of the building to form a Building Integrated Photovoltaics (BIPV) system. The carbon emissions during the building operation stage are shown in **Table 4**.

Table 4. Calculation results of carbon emissions during building operation

Type of energy consumption	Annual power consumption （kW·h/a）	Carbon emission factor (tCO_2e/kW·h)	Annual carbon emissions (tCO_2e)
Heating system	1350	0.928×10^{-3}	1.25
Lighting and hot water systems	65.7		0.06
renewable energy (Solar)	21450		-19.9
Total	**19415.7**	**--**	**-18.59**

4.5. Calculation results of carbon emissions during the demolition phase

The carbon emissions of the building demolition stage are the carbon emissions generated by the use of various energy consumed by the machinery and equipment used in mechanical demolition, the total carbon emission is $0.3tCO_2e$.

4.6. Comparison of carbon emissions at different stages of the building

The carbon emissions of the whole life cycle of buildings are shown in **Table 5**, the carbon emissions of building materials production and transportation stage are 115.04 tCO_2e, and the carbon emissions of building construction stage and photovoltaic construction and transportation stage are 60.47 tCO_2e. The average annual carbon emissions of photovoltaics in the building operation stage are 19.9 tCO_2e, and the carbon emissions in the building demolition stage are very low and negligible. As can be seen from **Table 5**, buildings have been contributing carbon negative after the ninth year, contributing to the achievement of the carbon neutrality goal.

Table 5. Carbon emissions throughout the life cycle of buildings

Architectural design years (years)		70
Carbon neutrality time (years)		9
Building construction phase	Building materials production stage (tCO2e).	80.35
	Building materials transportation stage (tCO_2e)	34.69
	Construction phase (tCO_2e)	42.31
	PV module construction and transportation phase (tCO_2e)	18.16
Building operation phase	Heating system (tCO_2e)	1.25
	Lighting and hot water systems (tCO_2e)	0.06
	Number of replacements (times) during the life of the building	2
	Carbon emissions from photovoltaic replacement (tCO_2e)	90.2
	Carbon emissions from photovoltaic power generation (tCO_2e)	-19.9
Building demolition stage (tCO_2e)		0.3
Greening the carbon sink stage (tCO_2e)		-0.035
Carbon emissions throughout the life cycle of buildings (tCO_2e)		-947.54

5. Summary

Based on the HUI HOUSE of the 3rd China International Solar Decathlon Competition, this paper uses the LCA theory to study the HUI HOUSE from four aspects: building materials production and transportation stage, building construction stage, building operation stage, and building demolition stage for the Desheng Village project in Zhangbei County, Zhangjiakou City Full lifecycle carbon footprint analysis. In its operation stage, the building relies on solar power generation, and the battery storage mode can meet the daily needs of the building. On this basis, through the actual monitoring data of the building, the cumulative power generation of the building throughout its whole life cycle is predicted in order to estimate the contribution of the building in terms of social and economic benefits. According to the experimental results, it is clear that the building has made great contributions to energy conservation and emission reduction, and acts as a great reference for the design and construction of zero-energy houses, which is significant for the development of new directions of housing in the future.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Płoszaj-Mazurek M, Ryńska E, Grochulska-Salak M, 2020, Methods to Optimize Carbon Footprint of Buildings in Regenerative Architectural Design with the Use of Machine Learning, Convolutional

Neural Network, and Parametric Design. Energies, 13(20): 5289. https://doi.org/10.3390/en13205289

[2] Liu C, Zhang H, Luo B, Li L, 2022, A Quantitative Recovery Process of Rare Earth in Bastnaesite Leachate for Energy Saving and Emission Reduction. Minerals Engineering, 190: 107920.

[3] Jin H, Yang J, Chen Y, 2022, Energy Saving and Emission Reduction Fiscal Policy and Corporate Green Technology Innovation. Frontiers in Psychology, 13: 1056038. https://www.doi.org/10.3389/fpsyg.2022.1056038

[4] Sahoo N, Kumar A, Samsher S, 2022, Review on Energy Conservation and Emission Reduction Approaches for Cement Industry. Environmental Development, 44: 100767. https://doi.org/10.1016/j.envdev.2022.100767

[5] Wang S, Luo Y, Liu Z, et al., 2022, Analysis on Energy Conservation and Emission Reduction Efficiency and Influencing Factors for Ports Around Bohai in China Under the Low Carbon Target. Sustainability, 14(22): 14765.

[6] Bai Y, Gao Y, Li D, et al., 2022, Coordinated Distribution or Client Introduce? Analysis of Energy Conservation and Emission Reduction in Canadian Logistics Enterprises. Sustainability, 14(24): 16979.

[7] Shi F, Jin W, 2018, Research on the Design Concept and Type of Building Thermal Buffer Space: A Case Study of the International Solar Decathlon Competition. Southern Architecture, 2018(2): 60–66.

[8] Sun Y, 2018, Competition, Construction and Education: A Review of the 2018 China International Solar Decathlon Competition. Architectural Journal, 2018(12): 77-79.

[9] Seyedabadi MR, Eicker U, Karimi S, 2021, Plant Selection for Green Roofs and Their Impact on Carbon Sequestration and the Building Carbon Footprint. Environmental Challenges, 4: 100119. https://doi.org/10.1016/j.envc.2021.100119

[10] Ministry of Housing and Urban-Rural Development of the People's Republic of China and State Administration for Market Regulation, 2019, Standard for Building Carbon Emission Calculation, viewed November 12, 2022.

[11] Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2018, Standard for Green Performance Calculation of Civil Buildings, JGJ/T 449-2018, viewed November 12, 2022.

Journal of Architectural Research and Development, 2023, Volume 7, Issue 1
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Research on the Interior Decoration Characteristics of Peking Union Medical College Phase I Project

Qiqi Xiong[1], Bo Zhang[1]*, Yi Zheng[1], Xin Li[1], Yaqing Liang[2]

[1]School of Architecture and Art, North China University of Technology, Beijing 100144, China

[2]Beijing Ancient Architectural Design Institute Co., Ltd., Beijing 100050, China

***Corresponding author:** Bo Zhang, 1246106743@qq.com

Abstract: Peking Union Medical College was founded in the late Qing Dynasty and the early Republic of China. Since then, society and politics have been rapidly changing, and its architectural aesthetics reflect the idea of advocating the West and inheriting tradition. Through research and actual investigation, this paper summarizes the current status of its building from two aspects, interior decoration art and interior decoration technology, analyzes the interior decoration characteristics of Peking Union Medical College Phase I Project, and records the archives of Peking Union Medical College's decoration technology.

Keywords: Peking Union Medical College; Healthcare architecture; Interior decoration features

Online publication: January 17, 2023

1. Introduction

At the end of Qing Dynasty and the beginning of the Republic of China, with the invasion of China by colonial forces, there are various stages in the development of Chinese architectural forms, including Western classicism, Chinese and Western eclecticism, as well as Chinese classicism. As one of the unique architectural types, medical buildings have unique expressions in terms of interior decoration. Peking Union Medical College is a typical representative of this period, and its interior decoration reflects people's pursuit of Western aesthetics, technology, and knowledge. Based on the background of the times and field survey, this paper analyzes the interior decoration, artistic thoughts, and culture of Peking Union Medical College Phase I Project.

Peking Union Medical College was formerly the Union Medical College under the Anglo-American Church. In 1915, The Rockefeller Foundation of the United States acquired the Union Medical College and the real estate of Prince Yu's Mansion in Santiao Hutong, Dongdan, where it was rebuilt as Peking Union Medical College [1]. The school-building project was completed in two phases: Phase I was designed by Shattuck and Hussey, while Phase II was designed by architect Anner. This article focuses on analyzing the interior decoration characteristics of Peking Union Medical College Phase I Project, involving buildings 2 (Anatomy Teaching Building), 3 (Chemistry Building), and 4 (Physiology and Pharmacology Teaching Building), as shown in **Figure 1**, the curved corridors and porters, *etc*. The total construction area of the cultural relic is 7,392 square meters.

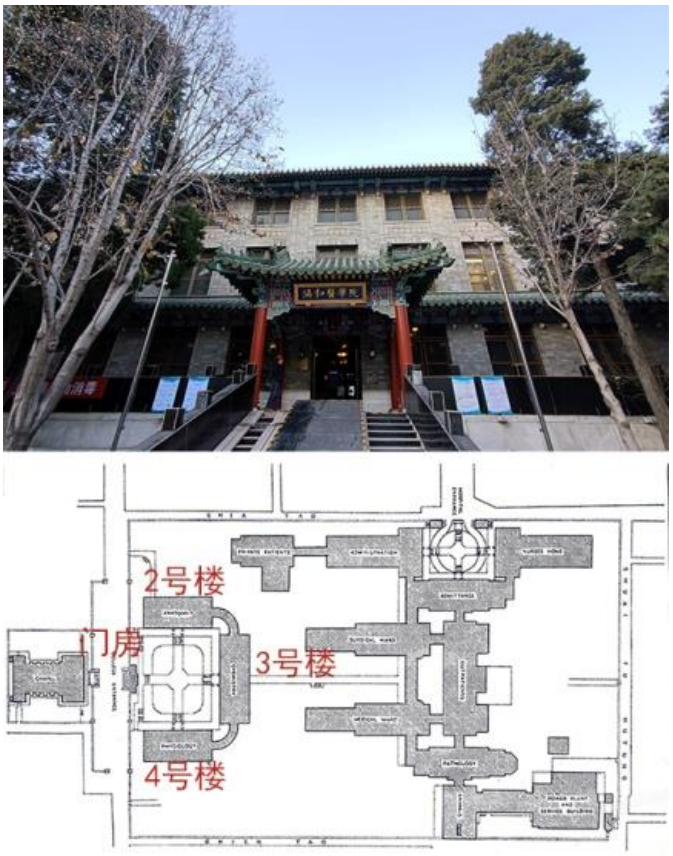


Figure 1. Union Medical College buildings and overall layout Clockwise: Building 2, Building 3, and Building 4.

Peking Union Medical College building has a long history, with outstanding architectural features, preserving the historical pattern and characteristics of the times. Its architectural construction is in the exploration and practice stages of modern Chinese eclecticism. While adopting advanced Western design ideas in the architectural layout, space design, decoration, and construction, it also integrates the traditional Beijing style into them. The design of the whole building embodies the ideas of functionalism and modernism, and its architectural form is an organic combination of both traditional Chinese culture and modern Western design.

2. Construction history

At the end of the 19th century and the beginning of the 20th century, there were many architectural design schools in the United States and advance technologies. The second industrial revolution brought about the "Electrical Age." As a result of various medical equipment, the architectural design requirements were higher. The rise of Chicago School in the United States compelled the construction industry and the German Manufacturing Alliance to pay more attention to functions and vigorously advocate industrialized buildings, respectively. Medical buildings require special designs due to their functions.

Before mid-19th century, most Western doctors believed that the air was what spread or even caused diseases. Even if the air quality is good in places where patients gather, such as hospitals, the source of disease can still be retained in building materials [2]. Hence, it is best to use impermeable materials for indoor application. At that time, the hygiene requirements of medical buildings had set them apart aesthetically from other building types; medical buildings were designed for therapy and occasionally for aesthetics. For example, Roxbury's New England Women's and Children's Hospital used rounded corners to facilitate air circulation and ensure sanitation, with no extra decorations and only a few furnishings and furniture. The ward faces and furniture are white to make sure that dirt does not get hidden by the color[3]

Early Chinese hospitals, however, were built by missionaries, who preached in the form of charitable diagnosis and treatment, and most of the medical buildings were full of religious overtones. For example, Guangzhou Boji Hospital initially could only rely on commercial activities for diagnosis and missionary work, and there were huge challenges in fund preparation and technical equipment [4]. The interior decoration of the operating room of Guangzhou Boji Hospital (**Figure 2**) was not as elegant as that of Western hospitals, and the medical cases were often straightforward ones.

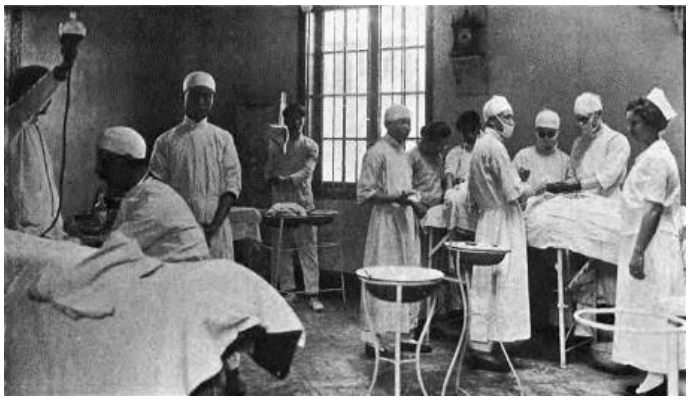


Figure 2. Operating room of Guangzhou Boji Hospital.

At the end of the 19th century, American medical practitioners gradually accepted Lister's germ theory and began to realize that it was the microorganisms floating in the dust rather than the air that caused the spread of diseases [5]. Given the concern toward sterility of medical environments and equipment, designers attempted to create a space that could be disinfected and began using waterproof, fireproof, soundproof, and corrosion-resistant building materials and finishes that met the needs of the time. They further strengthened the requirements for interior details, such as rounded corners, seams, and protrusions. However, in ordinary medical teaching places, wards, and other spaces, the requirements for impermeable indoor materials are not as high because the indoor moisture would condense on waterproof materials and deposit a large amount of bacteria and viruses.

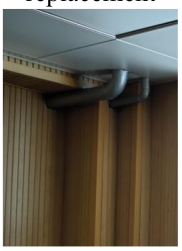
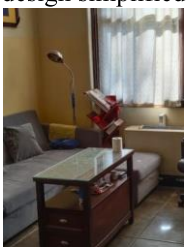
At the beginning of the 20th century, Western medicine was the means of missionary work by the early church, but the Qing Dynasty banned Christian missionary work. As a result, European and American churches learned the lesson of "conflict between people and religions," and thus adopted a large number of traditional Chinese architectural elements in the appearance of buildings to strengthen the "localization of Christianity" [6]. Peking Union Medical College combined Western medicine with Chinese civilization, hoping that the Chinese people may learn to accept Western medicine. Peking Union Medical College received special attention from The Rockwell Foundation and "borrowed" from Johns Hopkins University in terms of its overall layout and teaching [8]. In addition, American technology was adopted in most of the design and construction of Peking Union Medical College, while its appearance predominantly reflects traditional Chinese architecture. After He Shi designed the general drawing and building plan and elevation of Phase I Project, he sent the design drawings, including the structure, equipment and building construction details, back to the Chicago office for improvement, and subsequently modified the construction with regard to the actual situation of the project [8].

3. Current status of interior decoration

Peking Union Medical College building has been in use for a hundred years since its completion, which has already exceeded the 50-year service cycle of general building structure safety design. Although it has been repaired and protected many times, it is damaged by various factors during the use process, and the

original appearance of the cultural relic has also changed tremendously during the repair process. Following on-site investigation and comprehensive research, the main reasons for the damage of this cultural relic are attributable to three aspects (**Table 1**).

Table 1. Current practices and damage survey of Peking Union Medical College building

Building part	**Ground and baseboard**		**Wall**		
Damage type	Original material replacement	Surface damage	Original material replacement	Original paint color design simplified	Skin paint damage
Current situation and location	 Corridor on the first floor of building 4	 Office 1–4 on the first floor of building 4	 Farewell room, B1, building 2	 2–5 on the second floor of building 4	 Lower ground floor of Building 2, building 3
Current status, basic practices, and damage	The original terrazzo floor and skirting line were changed to black tiles	Damaged surface material	Wood veneer is applied behind the wall	In the later stage of wall maintenance, the original decoration was simplified, the paint was changed to light yellow, and the waistline was omitted	The wall skin is damp and peels off
Damage cause analysis	Human factors	Natural factors	Human factors	Human factors	Natural factors

First, natural factors. After a hundred years of wind, sun, rain, weathering, seasonal freezing, structural aging, *etc*., problems including the decay of wooden components, hollow plastering of walls, molding, weathering of stone cultural relics, cracking and alkali weathering of wall bricks, partial decay of doors and windows, corrosion and damage of detailed components, *etc*. are evident.

Second, human factors. Due to the needs of use functions, improper interventions that can damage the value of the cultural relic have been carried out, and due to difficulties in management, maintenance, and funds, the management and maintenance of the building have not been in place, thus further aggravating the architectural diseases and resulting in an aggravated damage to the authenticity of the original site.

Third, design constraints of the historical period. Peking Union Medical College building was built a hundred years ago. According to the engineering practices, quality requirements, and materials at that time, the stressed components of the building were lower than the requirements of the existing codes in terms of structural strength, deformation, and stability.

4. Characteristics of interior decoration art

He Shi designed according to the latest hospital specifications in the United States and sent the design drawings back to the Chicago office to improve on the details. At that time, the American design style and technology were adopted for its interior decoration [7]. As shown in **Figure 3**, the interior decoration of

Ward 2 of Brigham Hospital in Boston in the 19th century was layered with paint colors and designed with a waistline. With the development of social productivity, the constant temperature room in Peking Union Medical College is rarely used, and its interior decoration remains the same. The old photos of the Parasitology Laboratory in building 4 show that the interior decoration of American medical buildings is still used.

Figure 3. Interior decoration of Peking Union Medical College and interior decoration photos of American hospitals at the same period. (a) Interior decoration of Ward 2 at Brigham Hospital. (b) Historical photo of the original board room in Building 3. (c) A historical photograph of the parasitology laboratory in Building 4. (d) Photo of the thermostatic chamber on the first floor of Building 3. (e) Interior baseboard decoration method.

In order to create a sterile environment, the room needs to be frequently cleaned and disinfected. Restricted by the technology of the times, terrazzo, marble, cement, and other materials are often used as building interiors for high-strength anti-corrosion requirement. Historically, in terms of interior color and material matching, the decoration of the interior skirting line of Union Medical College building is mostly consistent with the materials used on the ground. At the same time, in view of the function of the room, terrazzo is used for the floor and the baseboard as an anti-slip treatment in the laboratory; in the library and important offices, the indoor baseboard and furniture cabinets are combined, as shown in **Figure 3E**. The activity requirements for interior arrangement are no longer as harsh as in the 19th century.

Although the style of decoration in most rooms changed during later maintenance, historical evidence can be found from old photos of a few reserved rooms and wall foundations. The wall color of some rooms is light yellow, whereas that of key rooms is red. Meeting rooms, boardrooms, and other important public rooms such as libraries have more prominent colors and decoration materials. The original director's room (**Figure 3B**) is the first room located in the southwest corner of building 3. The upper wall of the dado is dark, the top surface is white, and the wall is transitioned with plaster moldings. The paint that was repaired later was removed during the investigation. It was found that the wall bases of many rooms decorated with wooden dadoes were in palace wall red, so it is speculated that palace wall red was used for the original wall decoration.

Although most of the rooms and some indoor thermostatic rooms are painted, they are delicately handled in terms of color and visual division. Buildings 2, 3, and 4 are mainly laboratories and offices; they have simple decoration styles and the same color scheme for their walls. As shown in **Figures 3C–D**, a darker khaki was used for the lower part, light yellow was used for the upper part, and a lighter white was used for the ceiling. A brown waistline divides the wall, and the transition between the two colors is seemingly natural. The construction requirement of the overlapping parts of the two colors on the wall is unnecessary with the waistline design. In some rooms, a thin waistline is designed under the thick waistline to reduce the visual impact of the thick waistline. In other rooms, only a light-yellow base is seen after

removing the topcoat. It is speculated that some rooms are relatively simple and only use light yellow paint for decoration.

In view of the long history of the capital city of Beijing and the strong traditional concepts of the people, the design of Peking Union Medical College does not blindly imitate the design of American medical buildings or royal palaces. At that time, the facade of the building was in a plain color style of blue bricks of Beijing courtyard house, the roof was made of royal green glazed tiles, and the exterior decoration was decorated with colored paintings. Due to the special architectural functions of the medical school, the interior decoration is simple, but it still retains Chinese characteristic elements. The interior of Peking Union Medical College library retains the royal vermilion, while the darkroom, storage room, professor's studio, and other rooms with low hygiene requirements are covered in yellow paint. The building, as a whole, not only retains the traditional Chinese architectural style, but also incorporates American architectural design concepts, thus making it easier for Chinese people to accept Western medicine.

After the Opium War, Western culture began to invade China. Designers began to think about the differences between Chinese and Western cultures and the progress of the Western technology era, and actively explored new creations of traditional Chinese architectural forms. Whether it is the architectural appearance or interior decoration, it is a witness of the cultural exchange between China and the West. Paul Monroe, one of the original proponents of Peking Union Medical College construction project, proposed during the project inspection that newly built schools in China should combine Eastern and Western cultures and learn from each other, steering clear of the appearance of buildings transplanted from abroad [8]. The construction of Peking Union Medical College reflects the change of social consciousness in the early period of the Republic of China and the emancipation of people's minds. It also reflects the combination and development of traditional Chinese architecture and Western architectural technology as well as the various influences brought on by the aggressive forces in China.

5. Characteristics of interior decoration technology

5.1. Indoor fillet treatment

The sterile environment required by medical care has strict requirements not only on indoor walls, floors, ceilings, *etc*., but also on movable furniture, medical equipment, *etc*. Rather than breaking down the traditional link between the built environment and disease incidence at that time, hygiene concepts and germ theory simply reinforced the link between hospital building materials, design, and hygiene. In order to create a better aseptic environment, materials such as polished lacquered wood, marble mosaics, and glass are extensively used in the aseptic environment required by the hospital. In the late 19th century, New York hospital directors tested certain building materials to determine the least absorbent ones to reduce the risk of retaining infectious materials. Lime and white mortar proved to be the least absorbent materials for walls at that time, while terrazzo was used for floors [3]. Most of the finishes and furniture of the wards are made of smooth and hard materials, with no extra decoration used. In addition, most of the indoor corners and corners are rounded to facilitate air circulation and cleaning.

Union Medical College adopted the idea of creating a sterile environment like American medical buildings at that time, but because it retained the characteristics of traditional Chinese architecture, a lot of wood is used. It may also be due to the dry climate in Beijing and the low possibility of bacterial growth and retention. Moth-proof and water-resistant teak is used for the external purlins and dougong, while economical oak is used for the interior floors and furniture of the professor's studio and library. As shown in **Figure 4**, the external and internal corners of the interior walls are rounded, unlike today's streamlined interior design, where the mortar on the wall surface is treated with arcs to soften the space. In addition, the junction of the skirting line, the wall and the ground, the window sill, and the corners of the furniture are all treated with arcs for convenience of sanitation and cleaning as well as the prevention of dirt accumulation.

Considering that high places such as high window sills and furniture tops are not easy to clean, the top plane is inclined to minimize the amount of dust accumulated.

(a) 内墙阳角圆弧处理　(b) 室内阳角圆弧处理　(c) 室内窗台倾斜处理　(d) 家具顶部倾斜处理

Figure 4. Indoor fillet treatment of Peking Union Medical College. (a) The circular arc treatment of the inner wall exposed corners. (b) Arc treatment of indoor exposed corners. (c) The sloped treatment of indoor windowsills. (d) Tilt treatment of furniture tops.

5.2. Sound insulation and heat preservation treatment of the walls

During the interwar period, due to rapid industrial development, urban noise, and high building density, the space function design of American hospitals is ingenious; the functional requirements are carefully matched with the wall and floor materials; and hygiene, cleanliness, acoustics, fire protection, and so on were considered in the design. In the early 20th century, Stevens designed the soundproof wall "Stevens System" for Royal Victoria Hospital (**Figure 5A**). The walls use hollow bricks for sound insulation and keels to create the air layer and the outer veneer layer. They are then filled with felt and other materials to enhance the sound insulation effect. He also recommended thick felt-wrapped pipes and vents and acoustic plaster mortar on the interior walls [9]. In consideration of fire protection in the design of hospitals, architects usually choose to use fire-resistant materials, such as hollow clay tiles, bricks, stones, and concrete floors. Even old buildings have undergone modern fire protection improvements [10].

(a) 蒙特利尔的皇家维多利亚医院墙体剖面的隔音系统　(b) 3号楼负一层恒温室墙体　(c) 4号楼二层实验室墙体　(d) 4号楼二层实验室楼板

Figure 5. Wall section of the American hospital and the sound insulation and heat preservation treatment of the wall of Peking Union Medical College during the same period. (a) The soundproof wall "Stevens System" for Royal Victoria Hospital. (b) The wall of the thermostatic chamber on the first floor of Building 3. (c) The wall of the laboratory on the second floor of Building 4. (d) The floor of the laboratory on the second floor of Building 4.

Union Medical College is located in Prince Yu's Mansion (**Figure 6**). To its south is the embassy area of Dongjiaomin Lane, a commercial trade area, which is surrounded by a large number of foreigners. The surrounding area of the base has a huge population, with dense buildings and mixed noise, so the need for fire prevention, sound insulation, and heat preservation has been taken into account by the designer. Since the blue brick masonry technology that is used in traditional Chinese buildings cannot meet the requirements, blue bricks are built as the outer layer of the wall, the interior is filled with thermal insulation materials, and hollow bricks are used to build the inner walls to achieve the purpose.

Figure 6. Site selection for Union Medical College Phase I Project. From top to bottom, the Forbidden City, Dongan Market, Wangfujing business District, Dongdan Cuisine Market, and the foreign diplomatic quarters are shown.

As shown in **Figure 6**, there are rooms with special needs. In order to configure a constant temperature room, special insulation materials are placed inside the brick walls, and asphalt and other materials are used to fill the joints. The walls of ordinary offices, laboratories, and other rooms are filled with hollow bricks. Moreover, the floor of the laboratory is made of several layers of hollow bricks. Historically, the experimental electrical equipment penetrated the floor directly, and the suspension bars were anchored directly to the floor of the upper floor, which to a certain extent destroyed the original intention of its fireproof and soundproof design.

Detailed-orientated humanistic care is evident in details such as sanitation, color, acoustics, and heat insulation in interior decoration. In order to meet the requirements of building sanitation and medical experiment teaching, He Shi kept architectural decoration and details to a minimum and was extremely restrained in aesthetics. However, interior decoration and details are still necessary elements of medical architecture to some extent. Considering the iconicity of the entrance of Union Medical College, the main entrance hall of the building complex is decorated with wood as a whole, with dignified and elegant wooden screens arranged. Considering the potential impact on students and professors, the teaching space is not pursued to be purely hygienic, but it is completely painted in white. The library and other rooms are not

only decorated with wood, but also painted with royal vermilion. Considering the impact of the surrounding environment of the base on teaching itself, the acoustics and thermals are extremely sophisticated. Being people-oriented by taking into account of the needs of all users is one of the ways for Chinese people to recognize and learn Western medicine.

6. Conclusion

The interior decoration of Peking Union Medical College building embodies the medical aesthetic culture during the early Republic of China, the ideological emancipation brought about by the colonial aggression forces, and the organic combination of local history and culture with Western technology. He Shi combined traditional Chinese architecture with advanced Western technology and design trends, which weakened the psychological resistance of the Chinese people and spread the theoretical knowledge of Western medicine. It is also one of the exploration forms of traditional Chinese architectural styles. This paper analyzes and summarizes the characteristics of the interior decoration of Union Medical College Phase I Project, providing a research perspective for the architectural practice of foreign architects in China and into the decoration characteristics of domestic medical buildings in the late Qing Dynasty and early Republic of China.

Funding

This work was supported by the National Key R&D Program "Science and Technology Winter Olympics" (Grant Number: 2020YFF0304900).

Disclosure statement

The authors declare no conflict of interest.

References

[1] Hao X, Qin Y, 2014, Architectural Styles of Early Chinese Hospitals: 1835-1928. Architectural Journal, 2014(11): 36–42.

[2] Ayliffe GAJ, English MP, 2003, Hospital Infections: From Miasmas to MRSA, Cambridge University Press, Cambridge, 28–90.

[3] Kisacky J, 2017, Rise of the Modern Hospital: An Architectural History of Health and Healing, 1870-1940, University of Pittsburgh Press.

[4] Hui J, Jones, 2009, Centennial of Boji Hospital (1835-1935) [Shen Z, Trans.], Guangdong People's Publishing House, Guangzhou, 44–45.

[5] Lister J, 1867, On the Antiseptic Principle in the Practice of Surgery. Br Med J, 2(351): 246–248.

[6] Qin Y, 2004, Chinese Expression of Modern Chinese Architecture. Architectural Journal, 2004(06): 20–23.

[7] Lin E, 1943, Background and Early History of the School of Nursing of the Peiping Union Medical College. RAC, FA065, Box D1:187.

[8] Liu Y, 2020, The Origin of American Progressive Thought and the New Exploration of Peking Union Medical College Campus Planning and Construction. Architectural Journal, 2020(09): 95–103. https://doi.org/10.19819/j.cnki.ISSN0529-1399.202009016

[9] Stevens EF, 1921, The American Hospital of the Twentieth Century, Architectural Record Publishing Company, New York.

[10] Adams A, 2008, Medicine by Design: The Architect and the Modern Hospital, 1893–1943, Univ of Minnesota Press.

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

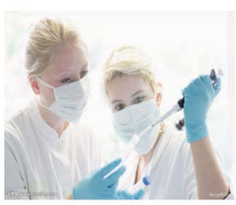
Innoscience Research (Malaysia), which is global market oriented, was founded in 2016.Innoscience Research focuses on services based on scientific research. By cooperating with universities and scientific institutes all over the world, it performs medical researches to benefit human beings and promotes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

China Collaborators

Oversea Collaborators

Hospital

University

Scientific institutions

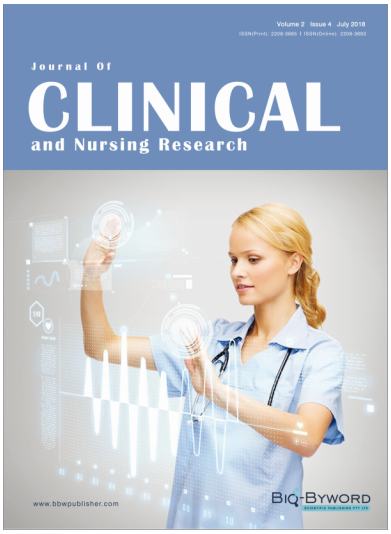
BIO-BYWORD
SCIENTIFIC PUBLISHING PTY LTD

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