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Comparative study of the construction mode of wartime air-raid shelters in Chongqing and London under the context of massive bombing

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Abstract

This paper aims to explore the construction of air-raid shelters by different cities utilizing advantageous resources to address the refuge needs of large populations. The study collects historical documents and conducts field research to categorize and comparatively analyze the characteristics of air-raid shelter construction in the capitals of China and the United Kingdom during World War II, taking into account the social context and natural conditions. Then the study assesses the advantages and disadvantages of different construction models. Facing the tragic bombings and to protect tens of thousands of people, the construction of air-raid shelters fully demonstrated different patterns in the two cities based on natural environments and industrial strength, i.e., the nature-oriented pattern and the industry-oriented pattern. The air-raid shelters in the two cities adopted various construction strategies in four aspects: location layout, relationship with buildings, internal space, and architectural technology and materials. Chongqing's nature-oriented construction pattern was more resilient and economical. London's industry-oriented construction pattern had the advantages of comfort, safety, and rapid production and construction. Two different construction patterns not only showcase the ingenuity of air-raid shelter architecture but also reveal the spirit of optimism, tenacity, and unity of the people in the capitals of China and the United Kingdom during the war. Nowadays, this research is of great significance for air-raid shelter construction and utilization, as well as for the shaping of urban identity.

Keywords:
Air-raid Shelters
Industrial-oriented pattern
Chongqing
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1. Introduction

During World War II, both Chongqing and London, serving as wartime capitals of their respective nations, endured severe aerial bombardments. Vast numbers of civilians faced immense wartime suffering, and urban air defense became a critical challenge. Today, the numerous surviving urban air raid shelters stand as significant historical witnesses, preserved or repurposed in various ways. Reflecting on these shelters now holds considerable strategic research value and historical commemorative significance.

For cities like Chongqing and London, protected by the natural barriers of the Yangtze River and the English Channel, bombing campaigns represented a deep-reaching strategic assault. These attacks were not

only aimed at destroying urban infrastructure but also at shattering civilian morale and inciting widespread panic. From February 1938 to August 1943, Japan carried out a relentless, five-and-a-half-year indiscriminate bombing campaign against Chongqing, the wartime capital of China. According to incomplete statistics, during this period, the Japanese military conducted 203 air raids, deploying 9,166 aircraft, dropping 17,812 bombs, killing 11,178 civilians, injuring 12,856 others, and destroying 17,452 buildings with a total of 37,182 rooms (Chongqing Civil Air Defense Office, 1994). The prolonged duration, brutal methods, and severe casualties of these bombings stand as rare examples in the history of human warfare. During the same period, another capital of another anti-fascist ally, London, also suffered devastating losses. Between September 1940 and May 1941, bombings resulted in the deaths of 15,775 Londoners, leaving one-sixth of the city's population homeless (Bell, 2009). Although the strategy of evacuating civilians to the outskirts of the city could mitigate some of the damage caused by the bombings, this approach ultimately yielded limited results. (Chongqing Municipal Government & Chongqing Provisional Senate). Therefore, the construction of air raid shelters became particularly crucial in safeguarding urban residents, maintaining industrial production, and preserving wartime morale. The urgent challenge was how to rapidly build numerous shelters in a short period. To meet this challenge, Chongqing and London each utilized their respective conditions to establish "second spaces"—air raid shelters—for citizens and institutions within just a few years.

Wartime air raid shelters refer primarily to spaces designed to protect civilians and sustain production, including air raid trenches, air raid rooms, tunnels, brick street shelters, reinforced rooms, basements, Anderson shelters, and Morrison shelters. In Chongqing, air raid trenches and caves were predominant, whereas London, in addition to trenches, included a wider variety of related air defense shelters. This study focuses on wartime air raid shelters, exploring the wisdom of the people in responding to the brutal impacts of war.

2. Overview of Wartime Air Defense Structures in Chongqing and London

Air-raid shelters constructed during wartime can be categorized into two types based on their construction and use: public air-raid shelters and private air-raid shelters. Public air-raid shelters are generally built and managed by the government, intended for use by the general public and public institutions. In contrast, private air-raid shelters are typically constructed by individuals for family use, serving as both a refuge for families during times of war and a repository of memories. Significant differences exist between the two in terms of construction standards and layout, which will be discussed separately in the following sections.

The construction of air-raid shelters in Chongqing, which involved either new constructions or the modification of natural caves within the mountainous terrain, underwent three distinct phases: preparation, government-led initiatives, and a combination of public and private efforts. As the political situation deteriorated, Chiang Kai-shek flew to Chongqing on March 2, 1935, declaring Sichuan Province as the base for national rejuvenation. With this, Chongqing's status was elevated, becoming a key strategic center during the war of resistance against Japan. From 1935 to October 1937, Chongqing hosted air defense exhibitions (Sichuan Monthly, 1935) conducted detailed surveys of city basements and entertainment venues along with their respective shelters, and held air defense drills (Sichuan Monthly Newspaper Office, 1937) to continuously raise public awareness and capability in air defense. Before 1937, Chongqing had only a small number of underground military fortifications and cellars, which were far from sufficient to provide shelter for the general population. The construction of simple air-raid trenches began in 1937, but the main period of construction occurred between 1938 and 1941. In November 1937, the wartime government relocated to Chongqing, and in February 1938, the Japanese forces carried out their first bombing of the urban area. This marked the beginning of the Chongqing bombing campaign. However, due to insufficient early preparations, the city severely lacked public air-raid shelters. Starting in 1938, the government took the lead in constructing public air-raid shelters and large defense tunnels, while also providing models of air-raid trenches to encourage the public to dig their own shelters (Chongqing Civil Air Defense Office, 1994). Additionally, the issues of cleanliness and safety in public shelters became focal points of concern. During periods of intensive bombing, although evacuation policies were implemented, relying solely on government-led construction efforts was still insufficient to meet the demand for indoor shelters for the public. In 1939, private air-raid shelter construction began to rise. Following the large-scale bombings on May 3 and May 4, 1939, the development of air defense projects in Chongqing saw a concurrent growth of both public and private shelters, with the pace of manually excavated shelters accelerating (Chongqing Civil Air Defense Office, 1994). In 1940, the Japanese Air Force expanded its scale and changed its tactics to implement long-duration fatigue bombing as part of the "Operation 101" plan. This exposed problems with ventilation and lighting facilities inside the air-raid shelters. On the evening of June 5, 1941, the infamous Tunnel Tragedy occurred, shocking both China and the world, with a death toll estimated between 2,000 and 3,000. In response, new air-raid shelter improvement regulations were issued, addressing issues related to ventilation, lighting, construction, and poison gas protection. The construction of air-raid shelters became more refined as a result. By 1941, the overall construction of air-raid shelters was largely complete. Chongqing's central urban area had a total of 264 public shelters and 1,033 private shelters, with a combined capacity to house 461,080 people (Chongqing Civil Air Defense Office, 1994). Among them, the largest was a major tunnel project completed in 1940, capable of accommodating 17,299 people (Liu, 1944). In 1942, the focus of air-raid shelter construction shifted

towards improving internal facilities. After 1942, the frequency of Japanese air raids decreased, and construction of air-raid shelters ceased in 1943. Chongqing's air defense fortifications were built amidst the ruins of shattered tiles, the relentless day-and-night bombings, and the civilian casualties. The entire population of the city, united and resilient, collectively forged a vast underground fortress.

The threat of aerial bombardment during World War I posed a significant danger to Britain, instilling widespread fear among the population and drawing the government's attention to the need for air defense measures. A nationwide effort was mobilized to construct air raid shelters in London, capitalizing on the country's industrial capabilities to build or modify 11 different types of air raid shelters (as outlined in Table 1). The development of London's air defense infrastructure can be divided into four distinct phases.The first phase began after the Treaty of Versailles in the aftermath of World War I, extending until 1935. During this period, the Home Office established an Air Raid Precautions (ARP) department to investigate and discuss potential threats of future air raids and appropriate countermeasures. However, progress in shelter research was slow, as the economic crisis of the 1930s led to reduced government spending. The second phase commenced in March 1936, when the formation of the German Luftwaffe heightened the perceived threat, prompting the British government to announce a rearmament program. The ARP department established the Structural Precautions Committee, which distributed manuals to guide households in adapting their homes for air raid protection. The Munich Agreement in September 1938 secured a brief period of peace before the outbreak of war, marking the transition to the third phase, during which the government placed greater emphasis on the construction of air raid shelters. In 1938, at the request of the Home Office, William Paterson and Oscar Carl Kerrison designed the Anderson shelter, which not only provided physical protection but also played a crucial psychological role in alleviating public anxiety. By 1939, the government had initiated efforts to modify existing buildings and construct various types of shelters. However, it initially refused to allow the use of the London Underground as a sheltering space. It was only later, following public protests, that the government sanctioned the use of the Underground for shelter purposes. Yet, as the Underground suffered damage from multiple bombings, the government began constructing deep-level shelters by the end of 1940. These shelters were completed in 1942, by which time the Blitz had largely subsided. In general, public air raid shelters became more sophisticated in terms of internal facilities, functionality, and services. In contrast, private household shelters were simpler in design, focusing primarily on protecting against shrapnel and building collapse. From a practical perspective, however, private shelters were considered more comfortable than public shelters, which were often overcrowded and unhygienic. A survey conducted in 1940 revealed that people preferred taking refuge in private household shelters over public ones (Bell, 2008).

Table 1. Types of public and private air raid shelters in Chongqing and London.

City	Shelter type	Ownership
Chongqing	Cave	Public/Private
	Trench	Public/Private
	Air-raid room	Private
	Tunnel	Public
London	Underground stations and tunnels	Public
	The deep level shelters	Public
	The refuge room	Private
	Trench shelters	Public
	Anderson shelter	Private
	Morrison shelter	Private
	Railway arches	Public
	Cave	Public
	Street COMMUNAL SHELTERS	Public
	Underground parking and cellar	Public/Private
	Reinforced basement	Public/Private

3. Comparison of Air Defense shelters in Chongqing and London

Under the threat of war, in order to protect public safety and maintain the functioning of the city, the construction of air defense shelters in the twin cities was accelerated and continuously improved. These shelters embodied unique architectural ingenuity in four key aspects: spatial layout, the relationship with surrounding buildings, the design of interior spaces and facilities, and advancements in materials and construction techniques.

3.1. Location Layout of Public Air Defense Facilities

The location and distribution of public air-raid shelters are closely related to the accessibility and safety of public refuge. Therefore, when constructing these shelters, two key factors must be considered: whether the environment meets the conditions for construction, and the distance from important urban spaces, along with the public accessibility from residential areas.

Figure 1. Air raid shelters on the cliffs of Chongqing city in 1941.

In Chongqing, public air-raid shelters are primarily located on cliff slopes, areas with convenient transportation, and places with high population density. The mountainous terrain and natural caves in Chongqing provide geological protection for the construction of shelters, reducing economic costs. The mountains are mainly composed of granite and sandstone, with relatively high hardness, enabling them to withstand intense attacks without collapsing. Workers can excavate horizontally into the rock (as shown in Figure 1).

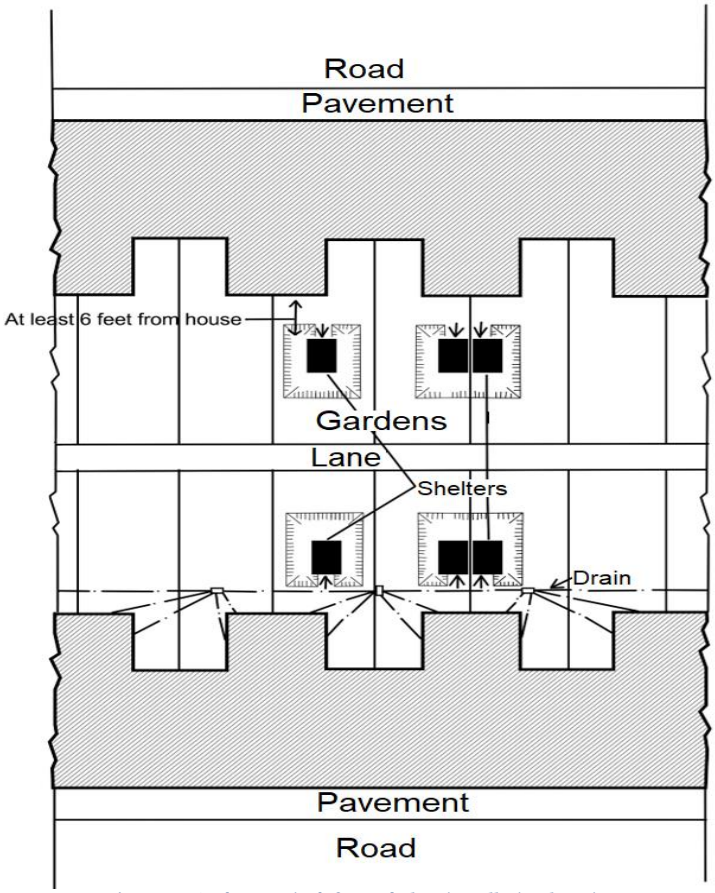

Figure 2. Anderson air defense shelter installation location.
Source: The Ministry of Home Office (1939).

Compared to flatland areas, the mountainous terrain of Chongqing reduces the amount of vertical shaft construction required, saving both labor and financial resources. Consequently, more than half of Chongqing's air-raid shelters are located along riverside cliffs. Many of the shelters are concentrated in the lower part of the city, where the terrain is steeper. In terms of accessibility, the entrances of these shelters are often located near roads and areas with dense populations. For instance, over ten air-raid shelters stretch along the South District Avenue, and many shelters are also situated around public spaces and buildings, such as parks, city walls, cinemas, schools, temples, and churches. The public air-raid shelter at the bustling Confucius Pool sports stadium can accommodate up to 3,400 people (Chongqing Resistance War Series Compilation Committee, 1995). During the war, it became common practice for visitors to ask for directions to the nearest air-raid shelter upon arriving at a hotel. When air raid sirens sounded, swiftly seeking shelter and scrambling for a seat in the bomb shelters became a distinctive aspect of life for the people of Chongqing during the war.

Compared to Chongqing, London's air defense shelters were more focused on utilizing existing spaces and accounting for the flow of people in their layout. New air-raid shelters were constructed with the needs of pedestrians in mind, and police would estimate the maximum number of people on the streets. The design of the location and capacity of air raid shelters is based on the maximum population of the street, ensuring that pedestrians can enter the shelter within ten minutes. Additionally, many of the air-raid shelters were repurposed from basements beneath public places such as churches, commercial buildings, and cinemas, while natural caves were located in the outskirts, limited by the terrain. During the Blitz, the relatively impoverished East End of London was the first to be bombed, and air defense infrastructure in this area was comparatively lacking. As one middle-class woman remarked, "The areas that suffered the worst bombings were mostly working-class neighborhoods. The courage of these people is astonishing... they are destined to endure all the other misfortunes as well."(Bell, 2008).

3.2. The Relationship Between Private Air Defense Structures and Building Layouts

Unlike public air-raid shelters, the design of private air-raid shelters places greater emphasis on convenient accessibility from personal or institutional buildings. Bombings often occur suddenly, particularly at night, making swift and easy access to shelter especially important for those who are asleep or engaged in their work.

The private air raid shelters in London primarily consist of Anderson shelters, Morrison shelters, and reinforced houses. Anderson shelters were designed for widespread distribution to the public. To achieve low material costs and affordability, these shelters mainly used galvanized corrugated steel sheets, which were relatively thin. To enhance their protective capabilities, the layout of Anderson shelters was often planned to utilize the shielding effect of nearby houses or by placing multiple shelters in close proximity (as shown in Figure 2). They were usually installed near houses or in back gardens. The distance between the shelter entrance and the house should be no less than six feet, allowing the house to provide additional protective cover The Ministry of Home Office (1939). This also facilitated quick access for residents during emergencies. However, if the distance exceeded 15 feet, the construction of a blast wall was recommended. Due to being located outdoors, these shelters had poor insulation and drainage, making them less comfortable for long-term habitation.

The Anderson shelters required garden space for installation, but not all London residents had such conditions. Therefore, the Morrison shelter, which could be placed indoors, was designed as an alternative. People inside a Morrison shelter could rely on both the house structure and the shelter itself to protect against collapsing walls (as shown in Figure 3). These shelters were typically installed on the ground floor or in the basement (The Ministry of Home Security, 1941a) with an ideal distance of two feet from the walls (The Ministry of Home Security, 1941b) to minimize potential harm. Families could sleep in the shelter at night or during air raids, and during the day, it could be repurposed as a dining table, ping pong table, or other functional uses.

Reinforcing one's own home to create an indoor shelter was also a common method of air raid protection. The preferred choice was a room with brick or concrete walls and as few doors and windows as possible (as shown in Figure 4). Inside the room, wooden pillars could be used to support the ceiling, and additional protection could be added to doors and windows using materials such as books, sandbags, wooden boards, or mesh screens (The Ministry of Home Security, 1940).

Figure 3. Morrison air defense shelter in use.

Source: Imperial war museum.

3.3. Internal Spaces and Facilities

The internal spaces of public and private air raid shelters varied significantly. The design of public air raid shelters took into account both the need for public refuge and the requirements for communal activities. In contrast, private shelters primarily catered to the daily needs of individuals and families. Despite the anxiety and fear during bombings, people exhibited optimism and resilience while staying in these shelters.

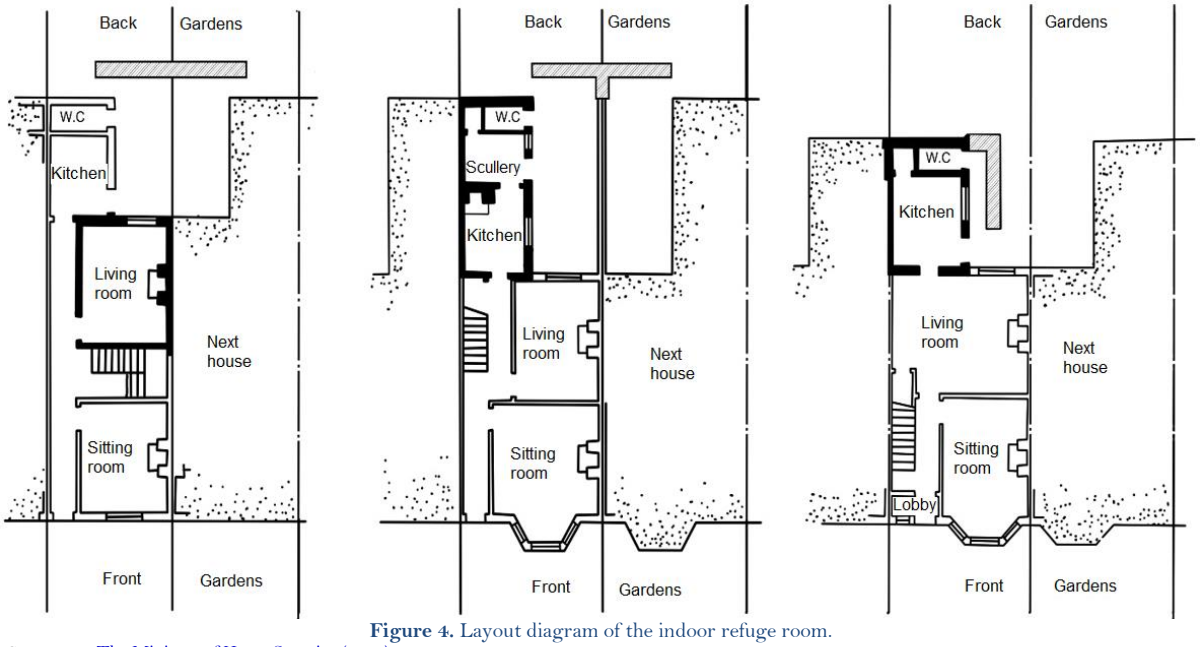

Figure 4. Layout diagram of the indoor refuge room.

Source: The Ministry of Home Security (1940).

In Chongqing, both public and private air raid tunnels were long, narrow, and interwoven. The internal space varied depending on the intended use and could be expanded as needed. Public air raid tunnels typically had widths of 2-4 meters, heights of 2.5-3.5 meters, and lengths ranging from tens to hundreds of meters, accommodating anywhere from dozens to thousands of people. The longest air raid tunnel was a connected series with a total length of nearly 2,500 meters, including entry and exit points (Chongqing Civil Air Defense Office, 1994). Private shelters were smaller, with sizes varying according to the status and needs of the occupants. Functionally, public shelters were relatively simple, with seating arranged along the corridors. Shelters used by government agencies included designated areas for different ranks or positions and spaces for

vehicles and equipment storage. Some private shelters, especially those used by the wealthy and influential, were carefully designed to meet personal living and work needs. For instance, the air raid shelter at Chiang Kai-shek's Huangshan residence had three entrances, with three Y-shaped passageways. A sentry post and an emergency operations command room were located at the intersection of these passages. The shelter was equipped with two generator rooms, storage rooms, ventilation, and explosion-proof facilities (Xing & Zhang, 2018). In his diary, Chiang Kai-shek described life there with his wife Soong Mei-ling, saying, "Despite the hardship, we found joy together." Furthermore, The Soviet Embassy spent 150,000 yuan to build an air raid shelter equipped with a bathroom, bedrooms, a bar, an office, and air conditioning, enabling people to stay underground 24 hours a day (Shen, 2016). During the early stages of air raid shelter use, several issues related to internal traffic flow arose. Public shelters often had too few entrances, making it difficult for people to enter and exit. Steep stairways caused people to slip, and overcrowding made inward-opening gates difficult to open. Lessons learned from tragic experiences led to improvements, such as adding multiple entrances connected by passageways. For example, the air raid shelter at Yanxi Cave had 13 entry and exit points.

Figure 5. Internal food elevator in the Yiyuan.

Private shelters were designed with emergency evacuation and air raid safety in mind, like the air raid shelter at Yiyuan, which connected indoor and outdoor spaces with narrow, winding passages. The entrance was narrowed and equipped with blast walls, and an internal food elevator connected to the above-ground portion to facilitate underground living (as shown in Figure 5). In terms of internal facilities, entrances often featured turning passageways or blast walls to absorb shock waves. Drainage channels and wooden benches were placed along the sides, with the roof supported by top plates and wooden pillars. However, in the early stages, these shelters lacked essential facilities such as ventilation, lighting, and drainage, posing serious safety risks. During hot weather, overcrowding led to stuffy, unpleasant conditions inside the shelters. After the tragic incident in the June 5th Tunnel, the "Preliminary Report on Technical Improvements to Air Raid Shelters" was issued, leading to improvements in ventilation, lighting, construction, and gas protection. For example, air raid shelters used the height of the entrances to facilitate natural ventilation, and ventilation shafts or blowers were added to resolve airflow issues.

Chongqing Air Raid Shelter Management Office (1941) Wooden toilets were placed outside the shelters (Guozhen, 1940). Over time, living conditions inside the shelters improved as people adapted to the circumstances, finding ways to entertain themselves, engage in conversations, and even create art. Despite the harsh and dark conditions, the people of Chongqing remained hopeful, united, and resilient. German friend Anna Wang wrote in her memoirs: "The diverse people living here are unforgettable to me. Regardless of wealth or status, everyone lived the same wartime life in the air raid shelters, helping and caring for each other—something unimaginable during peacetime" (AnnaWang, 1980). In addition to civilian air raid shelters, military factories that had relocated to Chongqing constructed a series of mountain tunnels to protect machinery from bombing and to maintain continuous production. These mountain workshops consisted of a network of main, auxiliary, and guide tunnels. The main tunnel workshops were about 3-6 meters wide and several dozen meters long, while the auxiliary tunnels were narrower, about 2 meters wide.

The internal design of London's air raid shelters demonstrated unique expertise in adapting existing spaces and ensuring multifunctionality. In terms of spatial layout, converted air raid shelters retained their original overall spatial structure, serving both everyday use and emergency shelter needs. Newly constructed

shelters prioritized efficiency, often using rectangular plans. For example, newly built street public shelters had rectangular plans enclosed by brick walls. The vertical space of Anderson shelters was fully utilized. In terms of functional layout, converted public air raid shelters allocated space for sleeping, toilets, medical care, and dining without altering the original overall structure. Although the internal space was relatively cramped and lacked dedicated public areas, people engage in activities in the shelters, such as entertainment, reading, and sleeping (as shown in Figure 6).

Figure 6. The social scene in London's public air raid shelter.
Source: Imperial war museum.

Figure 7. Anderson shelter used as a birthday celebration.

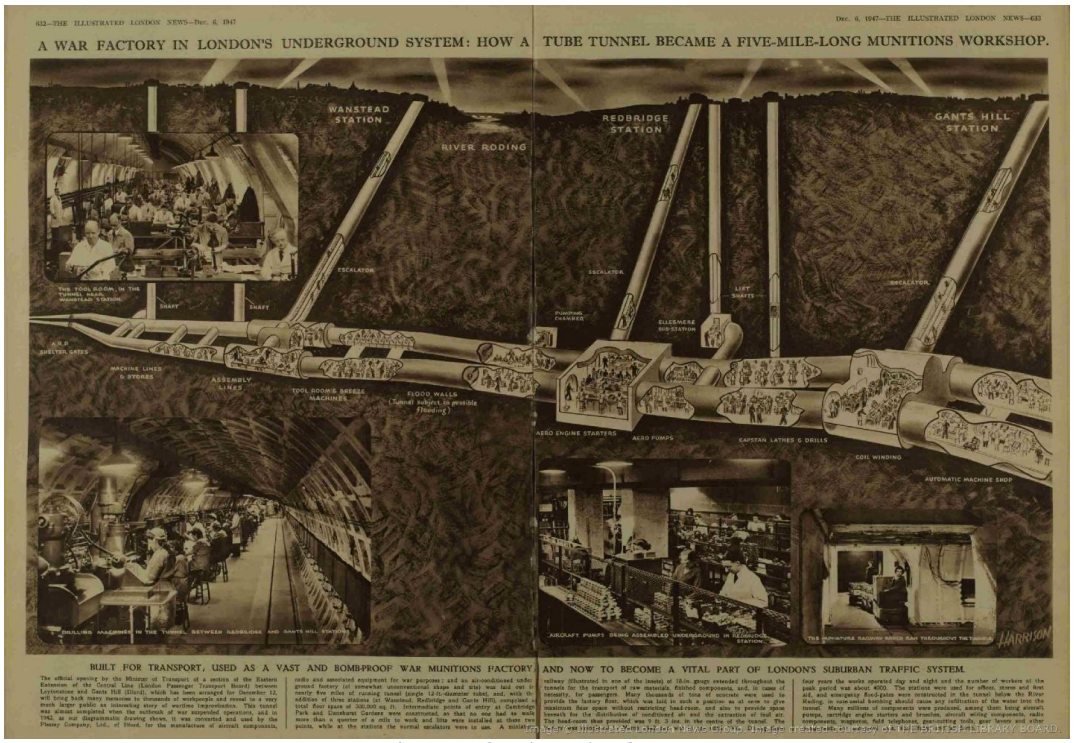

Figure 8. Plessy's wartime factory.

Source: Illustrated London News (1947).

Additionally, public activities like dart games, dances, and concerts helped alleviate boredom and boost morale. Private shelters were designed with a multifunctional approach. Anderson shelters made full use of vertical space within their confined and enclosed interiors by incorporating bunk beds and storage cabinets to meet sleeping and recreational needs. On special occasions, the interior space could even be arranged as a cozy birthday setting (as shown in Figure 7). In terms of internal facilities, public shelters improved capacity and living conditions by installing bunk beds, toilets, and stoves. To ensure daytime use, minimal modifications were made to subway tunnels. Besides providing shelter, unused subway tunnels were repurposed with additional rail tracks and production lines to serve as factories, ensuring the continuation of wartime munitions production (as shown in Figure 8).

3.4. Construction Techniques and Materials

The construction techniques and materials used in Chongqing's air raid shelters continuously evolved during the wartime period. In early 1937, Chongqing primarily built simple air raid pits and trenches. (Chongqing Civil Air Defense Office, 1994). Over time, the technical standards for air raid tunnels and trenches were gradually refined, with improvements made to site selection, geology, tunnel thickness, traffic access, dimensions, and mountain excavation techniques. The Chongqing Air Raid Shelter Management Office provided engineering guidelines for the construction of air raid shelters. For instance, suitable geographical locations for excavation were recommended to be on slopes or cliffs. To facilitate ventilation, drainage, and management, the entrances to the tunnels should be parallel, and the floor of the tunnels should be higher or level with the ground in front of the entrance (Chongqing Municipal Police Department, 1943). Regarding excavation methods, workers used explosives to drill and blast or employed traditional tools for manual digging (Guo, 2013; Yanhan, 1941). As a result, the demand for stonemasons and their wages far exceeded pre-war levels. The city was filled with the sounds of explosions and hammering, highlighting the significant role played by workers. Unfortunately, more than 40 stonemasons lost their lives while constructing air raid shelters between 1938 and 1939, sacrificing themselves to protect others. In addition, many experts at the time conducted research and published literature on air raid shelter construction, focusing on building mountain workshops and air raid shelters. Some experts compared and critically analyzed the tunnel excavation procedures used in countries like the UK, Germany, and Italy (Zheng, 1942). Based on the hardness of the rock and other factors, workers guided by academic research adjusted the amount of explosives, spacing, and depth accordingly. In terms of construction materials, the roof of an air raid tunnel required at least 4-5 meters of solid rock (Chongqing Air-Raid Shelter Engineering Department, 1942). Additionally, depending on the terrain, specifications, and economic conditions, safety was enhanced by using brick and stone arches, reinforced concrete walls, and steel-reinforced cement shelters at tunnel entrances. In cases where the geological conditions were not sufficiently robust, special procedures were required for the tunnel surface construction. For example, if the tunnel interior was damp, lime and charcoal could be laid under the floor, and

top plates and side panels could be added to absorb moisture and reduce dampness (Chongqing Municipal Police Department, 1943).

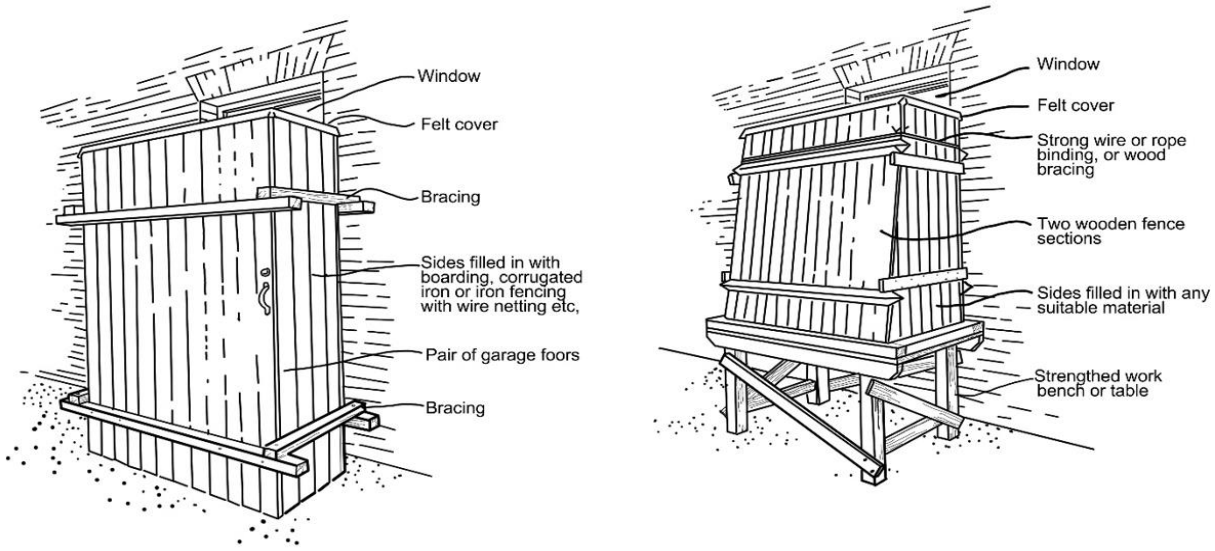

Figure 9. Interior shelter space retaining wall retrofit design plan.
Source: The ministry of home security, your home as an air raid shelter, (The Ministry of Home Security, 1941a).

Unlike Chongqing, where natural mountain terrain was adapted and utilized, London relied on its industrial base to rapidly modify and construct new air raid shelters. In terms of new construction techniques, London's family air raid shelters adopted a modular design concept, allowing for mass production and easy installation by the public. For instance, the Anderson shelters were assembled from corrugated steel sheets, thin plates, rails, and screws. The corrugated steel sheets were galvanized to improve durability and resistance to corrosion. People only needed to dig a pit and then follow the instructions to assemble the standard unit components. Similarly, the Morrison shelters were composed of modular components such as steel wire mesh, steel plates, and fasteners (The Ministry of Home Security). In terms of modification techniques, people placed barriers like boards, sand, and books in front of doors and windows to resist explosions and used coverings like wire mesh and screens on windows to prevent injury from flying glass shards Figure 9 illustrates two ways of making barrier outside windows using materials found in the house or garden. Additionally, wooden frames were used to support ceilings, and wire mesh was installed to prevent injury from collapses (The Ministry of Home Security, 1940) Regarding construction materials, as a pioneer of the Industrial Revolution, the UK had one of the world's most advanced industrial systems and production capacities at the time. In 1940, the UK's steel production reached approximately 13 million tons, accounting for about one-tenth of the world's steel production during that period (Colin, 2001). Consequently, the construction of London's air raid shelters predominantly utilized industrial materials such as steel and concrete, as seen in Anderson shelters, Morrison shelters, and deep-level tunnels. Furthermore, London's air raid shelter construction incorporated psychological theories, with the walls painted in a mixture of white and yellow ochre to promote psychological well-being.

4. Evaluation of Air Raid Shelter Construction Models

Chongqing's approach to air raid shelter construction emphasized a design model that harnessed natural resources, aligning with the philosophy of "Dao Operates Naturally." The city of Chongqing, due to historical development constraints, primarily consisted of wooden buildings, which were unsuitable for use as air raid shelters. Instead, Chongqing leveraged the protective features of its natural mountainous terrain, constructing shelters based on the surrounding topography, geological conditions, and their spatial relationship to existing buildings. The vast mountains and abundant wood and stone resources ensured the sustainability and cost-effectiveness of tunnel excavation, making the construction model resilient and reducing the strain on industrial resources during wartime. As the Ta Kung Pao editorial remarked, "Chongqing and its nearby air raid facilities owe much to the favorable terrain and rock formations. If we had to use iron and cement to build such vast, deep, and secure air raid shelters, it might cost five hundred billion yuan today, and still, it would be impossible." However, these shelters also faced safety risks due to rock weathering, varying rock layer thickness, inadequate protection of entrances, and insufficient deep ventilation. According to Hu Bohan, the Deputy Commander of the Chongqing Air Defense Command, "While many were killed by bombs for not taking shelter, even more lost their lives due to the weak resistance of the tunnels and the insufficient number of entrances, which led to them being sealed inside." Moreover, Chongqing is located in a syncline structure, which is an excellent water storage formation, resulting in cold and damp conditions within the shelters.

In contrast, London's air raid shelter construction adopted a strategy that combined new construction and reconstruction and relied on its strong industrial base, which had the advantages of comfort, safety, and the ability to be rapidly produced and distributed. The use of standardized designs and construction manuals, along with industrial techniques and materials, ensured public safety. In terms of comfort, the Morrison shelters provided a refuge within the home. However, outdoor Anderson shelters and public shelters still faced issues with cold and damp conditions. Regarding safety, scientific experiments and industrial materials offered robust protection. For widespread distribution, the modular design of the Anderson and Morrison shelters accelerated production. Installation manuals reduced the difficulty of assembly by the public and improved the speed, and both shelters were relatively affordable. However, the industrial-driven design model proved less resilient in the face of war. Shortly after the outbreak of war, London's cement resources were requisitioned by the government, and steel shortages led to the cessation of Anderson shelter production.

Figure 10. "Creating a new China out of the ruins" propaganda board.

Figure 11. "The more enemy bomb, the stronger people in Chongqing get" lettering on a wall during the bombing.

5. Conclusion

During wartime, both cities built air raid shelters based on their respective strengths, providing safety for their populations and offering valuable insights for future air defense construction. In terms of public location layout, the shelters utilized existing infrastructure while considering the convenience of human traffic. Regarding their relationship with building layouts, private shelters were situated close to buildings for easy access and to enhance safety, integrating them into daily life. Internally, the shelters emphasized multifunctionality, the ability to switch between peace and emergency modes, and provisions for entertainment and living. In terms of materials and technology, the shelters made use of local resources or adopted modular designs Figure 10 presents the government encourages the public to work and live with optimism, contributing to the rejuvenation of the nation. And Figure 11 presents the resilient will of the people of Chongqing under bombardment. The air raid shelters in both cities effectively protected the population, offering comfort and confidence, shattering the Axis powers' dream of breaking the will to resist, and fostering a spirit of resilience, solidarity, and mutual aid that laid the groundwork for eventual victory in the war.

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