

Resilient Design of Urban Parks in the Context of Public Safety Incidents

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Abstract: The resilient design of urban parks in the context of public safety incidents is an important topic concerning both urban and public safety. This research, from a resilience perspective, explores the design of urban parks under the backdrop of public safety incidents. It analyzes the problems faced by urban parks in terms of social, natural, and engineering aspects, and proposes four phases—prevention, early warning, emergency response, and post-disaster recovery—emphasizing the elements of each phase. Moreover, a resilient design strategy is put forth: “social—adaptive and versatile, embracing community sharing; ecological—balancing soft and hard elements, overcoming challenges with resilience; engineering—building a foundation for disaster prevention, intelligent early warning.” This strategy aims to enhance the resilience of parks, making them a crucial support for urban stability and public safety, while also providing valuable references for future urban planning and design.

Keywords: public safety, urban parks, resilience theory, design strategy

1. Introduction

Urban parks are an essential part of the urban ecosystem and landscape, and as such, they are an important part of the urban development process. They provide to the recreational needs of the local population by providing areas for relaxation, exploration, and social interaction, as well as the hosting of a variety of collective cultural activities. Incidents that threaten the lives, health, and property of a significant number of people and have the potential to disrupt public order include natural disasters, accidents, public health emergencies, and social security events. Over the course of the past several years, there has been an uptick in the number of occurrences involving public safety. For example, in 2019, Australia was impacted by catastrophic wildfires, which resulted in enormous loss. In the same year, Mumbai, India, was hit by protracted heavy rainfall and flooding, both of which led to significant damage and casualties. The COVID-19 pandemic that broke out in 2020 posed a significant risk to the health and safety of the general population. Not only do occurrences of this nature put people’s lives and property in peril, but they also shape the public’s impressions of urban parks and undermine their confidence in them. They can also have a detrimental impact on the towns that surround the city and the economy of the city, leading to a loss in the image and attractiveness of

parks in the city.

When confronted with a variety of public safety concerns, urban green spaces, which are essential components of cities, have the potential to play roles in the prevention of natural disasters, the provision of shelter in times of emergency, and the improvement of public health. These green areas possess positive relevance for the construction of urban safety systems when they are laid out rationally and arranged in functional configurations [1]. In the context of urban park landscaping, a multidisciplinary approach known as the resilience perspective provides an alternative viewpoint. It places an emphasis on the need of elasticity and adaptability in park systems and integrates the knowledge and experience gained from a variety of fields in order to deliver solutions that are comprehensive and systematic for urban parks. In addition, the resilience perspective incorporates a variety of research methodologies and tools, such as systems thinking, sustainability assessment, and community participation. These methods and tools make it possible to conduct an in-depth examination and evaluation of the practices that urban parks use to respond to incidents involving public safety. When viewed in this light, resilience design assumes an especially critical role in strengthening the ability of urban parks to effectively adjust to changing conditions. When planning and developing urban parks, resilient planning and design involves taking into consideration a variety of unknowns and prospective obstacles. This enables the parks to better cope with and adapt to the challenges that they face.

In light of this, the research that was carried out adopted a resilience approach in order to investigate the planning of urban parks in relation to occurrences involving public safety. It does this by establishing a research framework that consists of “theoretical foundation—problem analysis—strategic response.” This framework studies resilience design techniques for urban parks from social, environmental, and engineering perspectives. It offers unique concepts and methods for resiliently designing urban parks in the face of public safety incidents. The purpose of this research is to give fresh theoretical support and practical direction for resilient design in urban parks, with the end goal of supporting their sustainable development and inheritance. This study intends to make a substantial contribution to this subject by enhancing the safety of urban parks and promoting the sustainable development of these spaces through the conduct of in-depth research on the aforementioned topics.

2. Theoretical Foundation

2.1. Public Safety Incidents

Public safety incidents refer to events that occur in public places or areas and pose threats to public life, property, or social order. These incidents have broad social impacts, and addressing them effectively is of great concern. Based on the occurrence process, nature, and mechanisms of public safety incidents, as well as the characteristics of departmental management, they are generally categorized into four main types: natural disasters (floods, meteorological events, earthquakes, etc.), accidents (traffic accidents, public facility accidents, etc.), public health incidents (infectious diseases, unexplained epidemics, etc.), and social security incidents (major criminal cases, terrorist attacks, etc.) [2].

2.2. Resilience Theory

The Latin word “resilio,” which meaning to bounce back, is where the English word “resilience” comes from. It is the ability of a system to keep its structure, functions, and stability despite the presence of external shocks, changes, or dangers of collapse [3]. The concept of resilience is an interdisciplinary research strategy and mentality that was first developed in the study of ecology. Since its inception, resilience theory has seen widespread application in a variety of fields, including the environment, the economy, society, and organizations. It places an emphasis on the adaptability,

flexibility, and recovery capability of systems, which enables them to modify their structures and functions in a variety of different ways so that they can continue to be stable and sustainable. It is generally agreed that resilience theory is an optimistic, forward-looking, and invigorating style of thinking [4]. It has a wide range of applications, including urban planning, management of natural resources, social security, and organizational change [5-6]. In practice, resilience theory is used as a guide for formulating policies, conducting risk assessments, providing early warnings, allocating resources, and managing crises.

In the context of urban parks, incidents can occur that put the safety of park users and residents who live nearby in jeopardy, interfere with park operations or force them to be temporarily shut down, or provoke panic and psychological stress among members of the general public. As a result, resilience design assumes an even greater level of significance for the construction of urban parks in the context of occurrences involving public safety. Its purpose is to improve the park's adaptability, response capacity, and recovery ability, with the end goal of ensuring the health and safety of the general public.

3. Issues Faced by Urban Parks in the Context of Public Safety Incidents and Resilience Design Phases

3.1. Issues Faced by Urban Parks in the Context of Public Safety Incidents

3.1.1. Social Aspects

On the social front, issues primarily involve public safety concerns, panic, community confidence and cooperation, as well as societal stability. Specifically, public safety incidents can lead to decreased sense of security among park users and neighboring residents, amplifying public worries and fears regarding the park, consequently reducing its utilization rate. Trust between the park and the community could be disrupted, leading to decreased cooperation, impacting public participation and collective maintenance efforts for the park. Public safety incidents may incite social unrest, affecting urban stability and thereby disrupting normal park operations and services.

3.1.2. Natural Aspects

Natural aspects primarily comprise natural disasters and climate change. Natural disasters such as earthquakes, floods, and typhoons could severely damage urban parks, impairing park facilities and landscapes, and affecting the park's regular functions. Climate change might result in increased occurrences of extreme weather events such as heavy rainfall and high temperatures, consequently impacting park operations and visitor experiences.

3.1.3. Engineering Aspects

Engineering aspects encompass facility safety and resilience, emergency response plans, as well as resource allocation and utilization. Public safety incidents could damage facilities within the park, necessitating facilities to possess a certain degree of resilience and earthquake resistance to facilitate rapid recovery of functionality after a disaster. Furthermore, comprehensive emergency response plans are essential for addressing unforeseen events, ensuring the safety of park users. Lastly, in the face of public safety incidents, the park needs to strategically allocate resources, including personnel, equipment, and funding, to manage emergency situations effectively.

In summary, resolving these issues requires a comprehensive consideration of various factors encompassing social, natural, and engineering domains, and adopting corresponding measures and strategies. Resilience design can assist urban parks in better adapting to and addressing these

challenges, thereby enhancing the overall resilience and sustainability of the park.

3.2. Elements of Resilient Park Design in the Context of Public Safety

Based on existing research and the cycle of public safety risk management, the design of resilient parks in the context of public safety incidents can be divided into four phases: Prevention, Early Warning, Emergency Response, and Post-Disaster Recovery [7]. The comprehensive application of these elements across these four phases can significantly enhance the park's ability to respond and recover in the face of prevention, early warning, emergency, and post-disaster stages, thereby better safeguarding the safety and well-being of the public. Through the implementation of resilient design practices, urban parks can more effectively and robustly address challenges posed by various public safety incidents and ensure the safety and well-being of the general populace [8].

3.2.1. Prevention Phase – Risk Assessment and Facility Configuration

Conduct an assessment and analysis of potential public safety risks that could occur within the urban park and its vicinity, including natural disasters and social events, in order to identify latent risks and threats. Based on the results of this risk assessment, devise appropriate plans and configure the park's facilities and equipment, encompassing emergency shelters, secure pathways, disaster shelters, etc., with the aim of enhancing the park's disaster resistance capabilities.

3.2.2. Early Warning Phase – Monitoring and Alerting

Establish an effective monitoring system encompassing meteorological, geological, water level monitoring, and more, to gain real-time insight into the changing environmental conditions and risk factors surrounding the park. Develop a robust early warning mechanism that disseminates pertinent information to the public via the alert system, thereby alerting individuals to potential public safety risks and encouraging preventative measures.

3.2.3. Emergency Response Phase – Emergency Mobilization

Formulate comprehensive emergency plans outlining the roles and responsibilities of various departments and entities to ensure swift response and action in the event of a public safety incident. During the emergency response phase, mobilize a variety of resources including rescue personnel, emergency supplies, communication devices, and others, to provide rapid support and aid.

3.2.4. Post-disaster Recovery Phase – Addressing Physical and Mental Well-being

Conduct an assessment of the urban park following a public safety incident, gauging the extent of losses and impacts, and providing data to support post-disaster recovery efforts. Prioritize the physical and mental well-being of park users and staff, offering essential psychological counseling and support to aid in their swift return to normalcy.

3.3. Management and Application of Resilient Parks

The orderly progression of management and application is a prerequisite for the effectiveness of resilient parks. Through multi-party collaboration, the resilience and responsiveness of parks can be comprehensively enhanced. The systematic management and application of parks, coupled with active engagement from relevant departments and the public, are pivotal in ensuring the significant role of resilient parks in public safety incidents. Furthermore, the management and application of resilient parks constitute an integrated process involving comprehensive planning and design, risk

assessment, early warning systems, emergency plans and drills, resource allocation and emergency rescue, post-disaster recovery and social support, public education and participation, technological innovation, and scientific research, among other elements. By holistically managing and applying these key aspects, resilient parks can flexibly and efficiently address challenges in the context of public safety incidents, ensuring that parks continue to play crucial social and environmental roles. Simultaneously, this also contributes to enhancing the overall resilience and sustainability of urban development.

4. Urban Park Resilient Design Strategies in the Context of Public Safety Incidents

4.1. Social Resilience - Intelligent Adaptability, Collective Engagement

Amid public safety incidents, the social resilience design strategies for urban parks primarily focus on enhancing public sense of security, fostering community cooperation and confidence, and ensuring societal stability. Building close ties with community residents, involving the public in park planning and design processes, raising awareness about risks and preventive measures during public safety incidents, and fostering a collaborative, shared resilient park environment are key aspects. Through social education and outreach efforts, the public's disaster preparedness and self-rescue capabilities can be elevated, educating individuals on proper responses in emergency situations and minimizing disaster losses. Collaborating with communities to establish post-disaster resource integration mechanisms, utilizing the park as an emergency refuge, and providing essential resources and support further strengthen collaboration between communities and parks. Moreover, the construction of multifunctional units and intelligent adaptable elements plays a crucial role.

4.1.1. Multifunctional Units

Considering users' behavioral patterns and psychological needs in landscape design is vital, especially in the post-pandemic era where maintaining safe social distances has garnered attention. In urban park design, accommodating varying safe distance requirements for different scenarios is essential, ensuring the provision of safe and comfortable spaces for diverse groups. Edward T. Hall, the pioneer of proxemics, categorized four zones of subconscious spatial positioning between individuals: intimate distance (0-45 cm), personal distance (45-120 cm), social distance (120-360 cm), and public distance (over 360 cm). Landscape design has drawn upon this theory, designing urban parks as public spaces accommodating diverse quantities and types of people, be it individuals, families, or groups. Precision in these distances can create more comfortable spaces for users. Consequently, maintaining safe social distances has become a focus in the post-pandemic era.

Drawing from research on domestic and international theories and case studies, considering the characteristics of pandemic transmission and human psychological patterns, the integration of safe social distances with park zone characteristics, activity content, and modes has been proposed. This includes designing unit cells and combining them to form functional combinations adaptable to various urban park environments, meeting infection prevention needs within specific zones. These adaptable elements, providing infection prevention benefits while accommodating variable needs, are referred to as "multifunctional units."

Studying actual cases such as Vienna's "Distance Park" and the "Infection-Free" concept children's playground designed by Martin Binder and Claudio Rimmel, we learn that enhancing outdoor spaces with safe social distances can be achieved through visual guidance on flat surfaces and vertical spatial separations. The design of infection prevention-oriented multifunctional units comes in two forms: a flat single-plane design and a three-dimensional design combining flat and vertical planes. This combination of flat and vertical elements can create diverse spatial configurations and layered landscape effects, adapting to the specific functions of different park zones.

These units can be categorized into three types:

(1) Open Units

Open units (Figure 1) are primarily delineated on the flat plane, each area accommodating varying numbers of people while maintaining a minimum safe distance of 1.8 meters. Citizens can choose suitable units based on group size, while adhering to safe distancing guidelines. Units often take circular or other geometric shapes, customizable to various scenarios. Apart from circular division, units can be visually separated from surrounding areas through material variation or color differentiation.

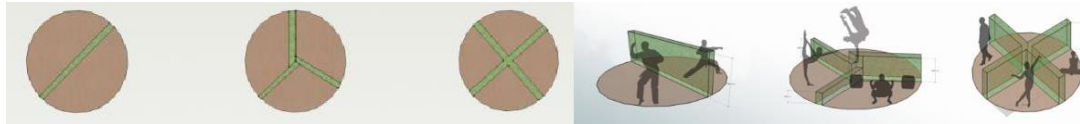


Figure 1: Open units.

(2) Semi-Enclosed Units

Semi-enclosed units maintain a safe distance of over 1.8 meters between units, creating diverse spatial effects through vertical design. Units can also be split and recombined to form various shapes and sizes. Large units are subdivided from within to create smaller units for multiple users. For single-user units, vertical design at the boundary lines ensures separation from peripheral areas.

Enclosure walls can be constructed from materials like anti-corrosive wood, plant fencing, bricks, and rubber. Heights range from 0.5 to 2.0 meters, adapting to different usage needs. Some walls are fitted with small windows, enriching façade forms with a blend of solidity and void. The use of greenery serves the purpose of separation while enhancing aesthetics, and plants also have a calming effect (Figure 2).

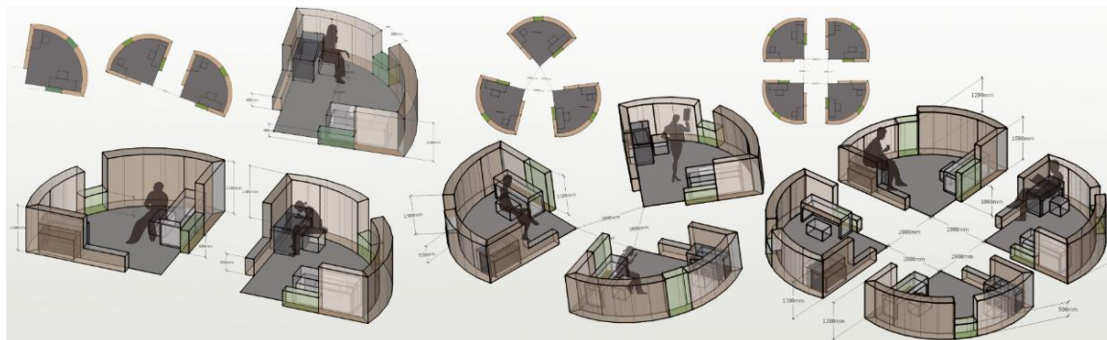


Figure 2: Semi-enclosed units.

(3) Enclosed Units

Enclosed units focus on creating quiet, secure spaces, isolating the area from surroundings as much as possible. These units have a single entrance to avoid repeated entry during use. Enclosure can be achieved using greenery, wood, bricks, rubber, and other materials.

In terms of conceptual composition, visual obstruction, permeability, and more, the design methodology for infection prevention-oriented multifunctional units aligns with conventional landscape design approaches. The only difference lies in incorporating social safety distancing considerations throughout each step of the design process, integrating scale and design techniques in roadways, vegetation, and landscape features. Furthermore, integrating medical and health perspectives, novel technologies are integrated into landscape structures to enhance infection prevention capabilities (Figure 3).

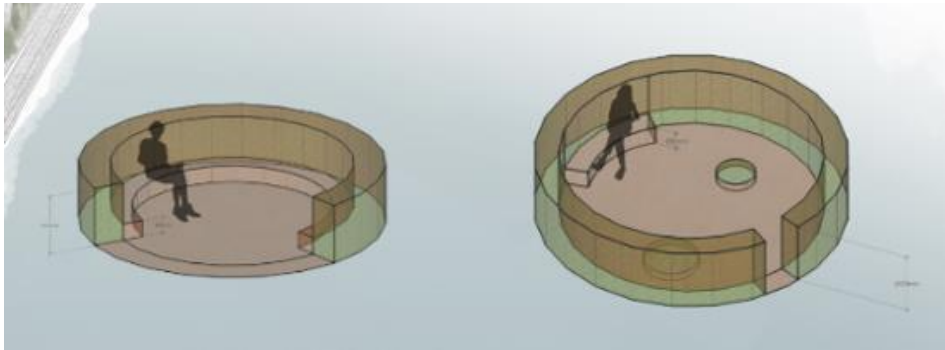


Figure 3: Enclosed units.

4.1.2. Intelligent Adaptive Elements

In the context of urban park social spaces, the resilience construction and enhancement should be guided by the diverse needs of different groups. Thus, in addition to clearing streets and alleys and optimizing node spaces, the introduction of “intelligent adaptive elements,” such as multi-functional sculptural walls and movable planters, into the park’s internal public activity spaces, as well as the incorporation of “intelligent gathering cells” that rely on surrounding buildings and supplement space functions, is advocated. This approach involves endowing the same facility or installation with multiple functional purposes to achieve multiple uses of the same space. This captivating and controllable process of transformation enriches the functionality of street and alley public spaces, fosters friendly development of social relationships, enhances space utilization efficiency in space-constrained urban parks, elevates the vibrancy within urban park interiors, and subsequently reinforces the park’s resilience against external risks (Figure 4).

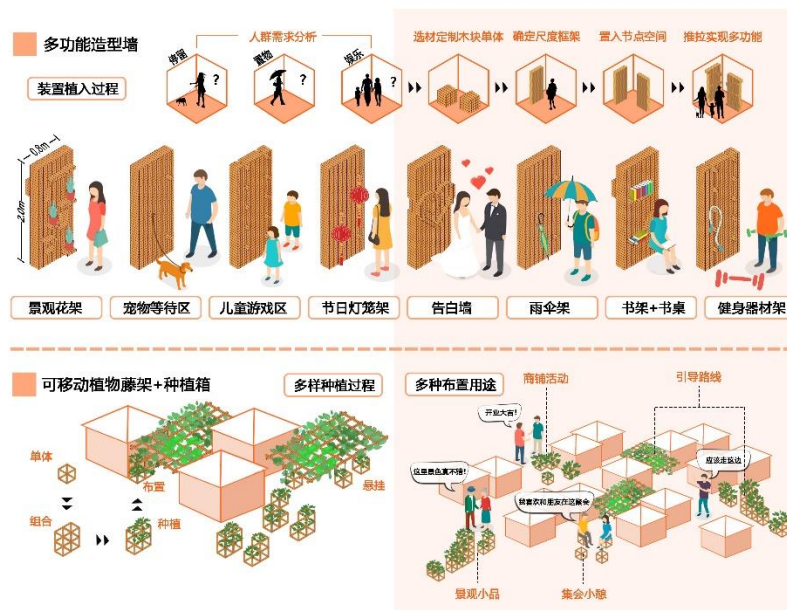


Figure 4: Intelligent adaptive elements.

4.2. Ecological Resilience - Balancing Flexibility and Rigidity, Overcoming Challenges with Tenacity

Ecological resilience primarily refers to the resilience of ecological spaces within urban parks, encompassing the natural elements of landscapes, vegetation, water bodies, and wildlife. The emphasis of ecological spaces lies in safeguarding and enhancing the natural environment, maintaining ecosystem stability, promoting biodiversity, and offering the public spaces for leisure and communion with nature. Resilient construction from an ecological perspective predominantly focuses on how ecological spaces resist external disturbances and restore equilibrium. Addressing ecological concerns necessitates reinforcing ecological restoration and conservation within parks, enhancing the resilience of natural ecosystems, including vegetation restoration, wetland preservation, and wildlife protection. Employing appropriate plant cultivation and ecological restoration measures aids in the self-recovery of ecosystems, mitigating the impact of natural disasters on parks. Confronting extreme weather events due to climate change involves park design and vegetation selection, favoring resilient plant species that are drought-resistant and wind-tolerant, thereby enhancing the park's adaptability to climate-related disasters. Additionally, prudent water resource planning and rainwater collection systems contribute to slowing urban floods induced by heavy rainfalls, bolstering drainage and flood prevention capabilities. At the ecological space level, the creation of a water-green ecological network is encouraged, with waterfront areas and green nodes as key management focal points. This involves organizing and linking ecological elements, fostering multiple penetrations of ecologies within spatial environments, particularly evident in the arrangement of functions such as guiding, observation, and activities. In response to the challenge of narrow and rigid waterfronts within the park, the strategy promotes the reshaping of versatile and resilient embankments, coupled with water purification measures. The “soft” aspect lies in human-centric waterfront arrangements, while the “hard” aspect involves ecological engineering methods that enhance water purification capabilities and address the necessity of waterfront environment management. Furthermore, attention to the sponge city concept is vital, necessitating the refinement of flood control and drainage facilities and the clearing of sediment in waterways. This strengthens rainwater management capabilities, underpinning the park's capacity for precise prevention and rapid response (Figure 5).

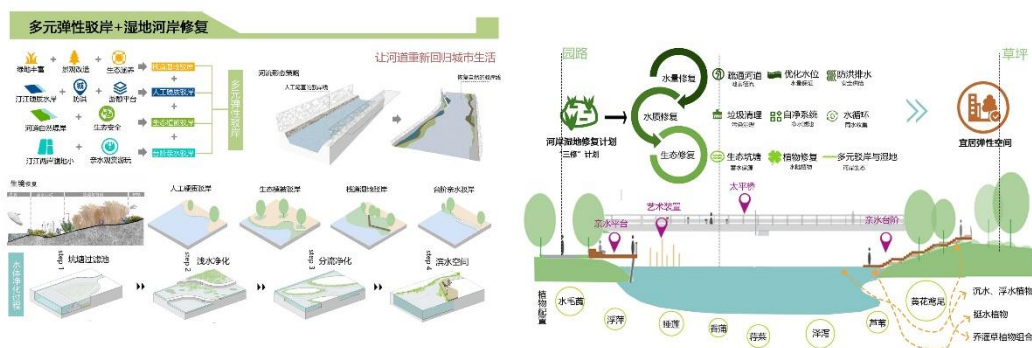


Figure 5: Ecological resilience strategies.

4.3. Engineering Resilience - Disaster-resistant Foundations, Intelligent Early Warning

Considering the engineering challenges urban parks face in the context of public safety incidents, the design of engineering resilience for urban parks becomes paramount. It primarily involves park infrastructure, architectural structures, and facility arrangements, referring specifically to built spaces within the urban park, encompassing buildings, facilities, roads, playground equipment, and other

human-made structures. These spaces are primarily intended to provide public services and amenities such as restrooms, resting areas, and children's play areas, catering to daily public needs, and also encompassing some management and maintenance facilities. In terms of facility disaster resistance, the design of park facilities and buildings incorporates engineering strategies against earthquakes, wind, floods, etc., ensuring that park structures and facilities remain sturdy during natural disasters. The selection of building materials, structural design, and facility arrangement should all take into consideration their disaster resistance, aiming to minimize destruction caused by disasters. Concerning emergency facilities, it's advised to strategically position emergency facilities like emergency shelters, medical stations, ensuring swift emergency response and support during crisis situations, catering to unforeseen events. These facilities should be thoughtfully situated to enable the public to quickly seek refuge and assistance, offering essential first aid and rescue functions. In the application of resilient materials, utilizing materials with resilience characteristics, such as renewable materials and impact-resistant materials, enhances the durability and disaster resistance of park facilities and equipment. Additionally, introducing intelligent management systems like disaster warning systems and monitoring systems can detect and provide timely warnings about potential disasters. Offering the public prompt safety alerts and guidance, these systems reinforce the park's preventive and emergency capabilities, ensuring the park maintains basic functions and services while swiftly returning to normal operation when faced with various safety incidents.

5. Conclusion

Against the backdrop of public safety incidents, the study of urban park resilience design emerges as a crucial undertaking to safeguard public safety and urban stability. This research unfolds across three dimensions: social, natural, and engineering. From a social perspective, the focus lies on public safety perception and community cooperation; from a natural standpoint, the emphasis is on preserving ecological environments and bolstering natural disaster resistance; and from an engineering standpoint, attention is directed toward disaster-resistant architecture and facility planning. Strategies such as the "Infection-Prevention Multi-Functional Units" facilitate outdoor spaces with safe social distancing, enhancing the park's emergency responsiveness. The implementation of engineering resilience strategies will expedite post-disaster recovery of park functionalities, providing the public with secure and stable venues. In future urban planning and design, the concept of resilience design should permeate every facet, rendering urban parks as pivotal pillars of urban safety and stability, allowing the public to find solace within these spaces and harmoniously coexist with nature.

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