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Study on Resilience of Urban Lifeline System

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Abstract

Resilient cities are not built to reduce the occurrence of disasters, but to make cities more tolerant, able to maintain normal operation in the face of disasters, reduce the losses caused by disasters, and enhance the happiness index of residents. In order to find out the solution to relieve urban problems, will toughness concept is introduced to study the urban lifeline system, analyzed the earthquake and the damage caused by meteorological disasters of lifeline system, and the toughness of transportation, water supply and power grid communication system research were summarized, and finally summed up the toughness urban development still existing problems and put forward the corresponding solution.

Keywords

Lifeline system; Urban resilience; Disaster.

1. Introduction

With the development of economy, China's urbanization process is speeding up. According to relevant statistics from the National Bureau of Statistics, in 2018, China's urban population reached 83.73 million and rural population reached 56.01 million, representing an urbanization rate of 59.59 percent and an urban population density of 2,477 people per square kilometer. With the increase of urban population, urban construction and urban life have exposed more and more problems, such as traffic congestion, housing shortage, water shortage and so on. These problems are characterized by "high uncertainty", "destructive" and "long duration", etc. In order to solve these problems, create a more livable environment and introduce "resilience" into urban construction. At present, China's Yiwu in Zhejiang province, Deyang in Sichuan Province, Haiyan in Zhejiang Province and Huangshi in Hubei Province have been selected into the "Global 100 Resilient Cities" project. Cities with strong resilience have strong adaptability to uncertain interference, while cities with weak resilience have insufficient adaptability to uncertain interference. Resilient cities are not built to reduce the occurrence of disasters, but to make cities more tolerant, able to maintain normal operation in the face of disasters, reduce the losses caused by disasters, and enhance the happiness index of residents. Zhang Mingshun[1] to cities such as toughness is defined as the city disaster can resist and absorb impact when hit, maintaining basic motion, and in a crisis, organization, and by learning to adapt to, in the ability to return to normal operation as soon as possible after a disaster, and puts forward six dimensions of urban toughness evaluation, economic, social and community capacity respectively, infrastructure, ecological environment and system. Shao[2] believes that urban resilience refers to the ability of a city to achieve normal operation such as public security, social order and economic construction through reasonable preparation, buffering and coping with the disturbance of uncertainty. David R. Godschalk[3] think urban resilience is the ability of local people to withstand extreme natural events without compromising their quality of life or productivity without massive assistance from outside their communities.

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Integrated experts and scholars to explain the toughness, toughness can be summed up as the definition of urban individual, community, system when suffering from disasters can withstand disasters, to some extent after the disaster damage functions to maintain their own basic operation and recover quickly and learn to adapt to the disaster, can ability to respond in a timely manner when the next disaster. In this paper, the resilience of urban lifeline system is reviewed in order to find solutions to enhance urban resilience and alleviate urban problems.

2. Concept of Urban Lifeline System

2.1. Definition of urban lifeline system

Urban lifeline system refers to a series of infrastructure to maintain the normal operation of the city and guarantee the daily life of urban residents[4], It mainly includes transportation system, water supply system, power grid communication system and other subsystems. The lifeline system is the "center" to ensure the normal operation of the city and the basic project to maintain the modern urban function[5]. Each subsystem is one of the lifeline system are not separate individuals, depend on each other, interaction between them, and if one of the system is destroyed, the normal operation of the other systems will contain. So the lifeline systems to them as a composite system, using a global perspective to study the relationship between each subsystem.

2.2. Resilience assessment of urban lifeline systems

So far, the research on the resilience of urban lifeline system is still in its infancy, with research directions mainly focusing on disaster prevention and mitigation resilience of lifeline system, community resilience and ecological resilience. There is no clear plan for the resilience assessment of lifeline system, but many scholars have begun to explore the assessment methods.

Chen an and Shi Yu[6]summarized and studied the evaluation indexes of urban resilience and summarized the construction dimensions of resilient cities(Figure 1). Based on the study of the resilience characteristics of experts and scholars, the author summarizes the three most important factors to measure the resilience of urban lifeline system: diversity, redundancy and integration.

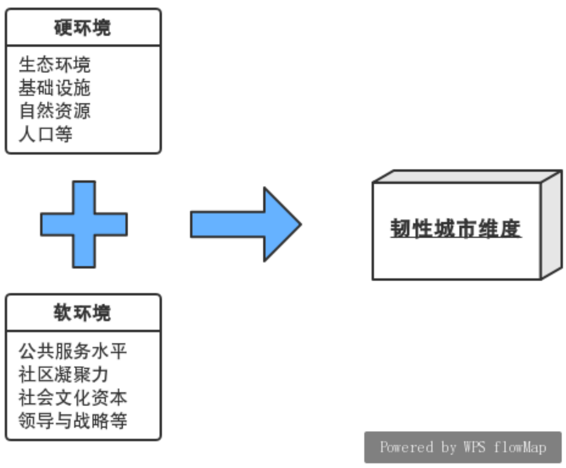

Figure 1 Building a resilient urban dimension

Stephanie E Chang and Masanobu Shinozuka[7] proposed that resilience assessment can be measured from two aspects: the extent of earthquake losses and the speed of urban recovery.

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Javier Rojo and others[8] think that the urban lifeline system are accurate and effective method of reliability assessment need to leverage their specific topology characteristics, the author introduces a sealed method to calculate the lifeline performance overall probability distribution of reliability index, the index by any number of main feeder, customer service availability (CSA) and load monitoring. And LIU Aihua[9] in order to study the resilience of urban lifeline system, the introduction of the brittle entropy theory and build the urban lifeline disasters sensitivity evaluation index system to evaluate lifeline toughness, the author from the mechanism of urban lifeline system, the interaction of the lifeline system is divided into functional, layout type interaction, alternative and xs interaction of these four types, the indicators and the comprehensive urban lifeline sensitivity calculation method are put forward.

According to literature review, it can be seen that the resilience assessment of urban lifeline system is still in the stage of theoretical research, and the relevant institutions have not yet defined the resilience assessment methods, and the feasibility of all methods is still worthy of verification. However, with the development of "resilience", the resilience assessment methods that are appropriate and in line with the current situation of the city will eventually be implemented.

3. Study on Disaster Mitigation Resilience of Lifeline System

It is impossible for human beings to build cities without disasters, but to build cities that coexist with disasters and adapt to disasters. There are many kinds of disasters facing cities, including natural disasters (earthquake, drought, flood, hurricane, etc.), human disasters (man-made explosion, fire, etc.) and disasters caused by modern weapons. Disasters cause more than 100 billion yuan in losses every year in China, and damage to urban lifelines may paralyze some functions of the lifeline system, according to People's Daily Online.

The resilience of urban lifeline system must be studied from the perspective of disaster. The resilience of urban lifeline system needs to be tested by disaster. Introducing the concept of toughness can not only measure the ability of the system to absorb external changes, but also measure its ability to adapt to the later environment and restore its preventive state. Resilient urban construction requires cities to have strong enough infrastructure to resist disasters and respond to the occurrence of extreme disasters in time. The performance response process of urban lifeline system after disaster event can be divided into three stages: disaster prevention stage, damage propagation stage and recovery stage[10].

Xi Jianglin et al.[11] proposed that urban "auxiliary" system planning should be taken into account when constructing urban lifelines, that is, the urban emergency management system should be built to ensure that the city has enough capacity to cope with disasters and reduce the losses caused by disasters. Susan L. Cutter[12] proposed that resilience indicator compliance can be used as a baseline condition to measure the effectiveness of plans, policies and interventions to improve disaster resilience.

4. Toughness of Each Subsystem of Lifeline

4.1. Transport system

The transportation system is a crucial link in the urban lifeline system, which connects the operation of the urban lifeline system. After a disaster, a well-functioning transportation network can enable the community to repair damaged infrastructure and quickly recover the economy. In a disaster, a well-run transportation system is critical to search and rescue, access to emergency personnel, evacuation and shelter, distribution of basic supplies, and the ability to respond quickly to urgent medical needs[13]. Traffic system function is to carry people or goods from the city to the destination city, transit in the event of accident, the effective method

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to restore the traffic system is to use another path connecting the two cities, the traffic between the two cities function recovery depends largely on whether there is in addition to the normal path of other bypass path[14].

As the transportation system plays an extremely important role in the healthy operation of cities, many experts and scholars begin to study ways to measure and enhance the resilience of the transportation system. Qiu Baoxing[15] puts forward the concept of "resilient urban traffic", which requires urban traffic to be elastic and able to resist impact. At the same time, the author puts forward five criteria for building resilient urban traffic, namely, diversity, modularization, high throughput, demand-side management and intelligentization. Andrew Cox et al[16] used DSER(Direct economic resilience) as the operational indicator of transport system resilience, which refers to the percentage of the maximum economic damage likely to be caused by a particular shock. The indicators that measure the resilience of a transport system mainly include the vulnerability, rigidity and flexibility of the transport system to unpredictable shocks, and the resilience of the transport system is measured according to the changes in transport patterns of passenger travel. Brian Donovan and Daniel b.[17]work with areas of the city by calculation between the pace of the history of the distribution (standardized travel time) and deviation of measured pace during abnormal events methods to analyze urban transportation infrastructure's ability to adapt to the hurricane, forge a represents the establishment of a comprehensive real-time analysis to measure the actual steps of infrastructure toughness measurement of urban traffic network resilience scale method.

4.2. Water supply system

Cities cannot live without water, which is essential for reducing the global disaster burden and improving the health, welfare and productivity of populations. Water is at the heart of adaptation to climate change and an important link between the climate system, human society and the environment. The key aspects of its toughness mainly include the redundancy of water distribution system, storage capacity of sewage collection system, structural integrity of water distribution and sewage collection system, and stability of drinking water, wastewater treatment and pumping facilities. The resilience of water supply system to disasters is one of the most critical aspects of disaster recovery[18].

Chien-hua Chiang[19] think such as earthquake damage prediction for water supply system should from damage to water supply pipeline and pipe network reliability analysis of two aspects, the introduction of GIS on the response of water supply pipe network of earthquake disaster intensity information timely to query, and the water supply system was established based on secondary development language Avenue the graphical user interface, seismic response simulation information system for urban water supply system provides the basis for the overall planning and design of the layout. LI qian[20] think-- that feed water system of disaster resilience is defined as a system itself against disasters and post-disaster system itself will feature the ability to recover quickly, and put forward in the face of toughness is reflected in water supply system when the earthquake resistance, absorption phase and recovery phase or three phase, the toughness index of water supply system is divided into seismic safety index and post-disaster recovery ability index. Michalis Fragiadakis and Symeon E. Christodoulou[21] through survival analysis, this paper proposes a new method of water supply system vulnerability assessment, this method combines the past non-seismic damage data and the vulnerability of network components of seismic load data, through the pipeline failure probability, using analysis (path count, the minimum cut sets) or numerical simulation method (monte carlo) to calculate the reliability of water supply system.

4.3. Grid communication system

Grid communication system as part of the urban lifeline system, daily operation of city has the indispensable role, but the city has experienced all sorts of disasters to the destruction of the

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urban power grid system has to happen from time to tome, in order to increase the network communications system to resist the ability of the disaster, in disasters occur to maintain normal electricity city, experts and scholars on the toughness of the system were studied. Zhou Xiaomin[22] defined the resilience of power grid system as the ability of power grid system to withstand disasters when disasters occur, and the ability of power grid system to effectively maintain a high level of operation and quickly recover to the normal state when the system performance is reduced due to insufficient resilience, so as to minimize load loss. Enhance the toughness of the grid system is needed in advance to evaluate system resilience, grid system evaluation index mainly includes power grid failure rate, failure of system components and system recovery time, the influence of Gao Hai-xiang[23] put forward such as from the technical, organizational, social, and economic four Angle (TOSE) toughness evaluation matrix was established, and put forward the preventive measures before and after a disaster recovery measures and toughness disaster emergency system in order to improve the power grid system. Bi-yun Chen, etc[24] in the typhoon, for example, the city power grid communication system are studied in front of the disaster to ensure normal power supply capacity should take the measures, the author proposes a distribution network of typhoon resistance evaluation model (as shown in figure 4.1), the synthetic evaluation of different typhoon scenario proposed grid toughness of three indicators, grid absorption rate, adaptive rate and repair rate respectively.

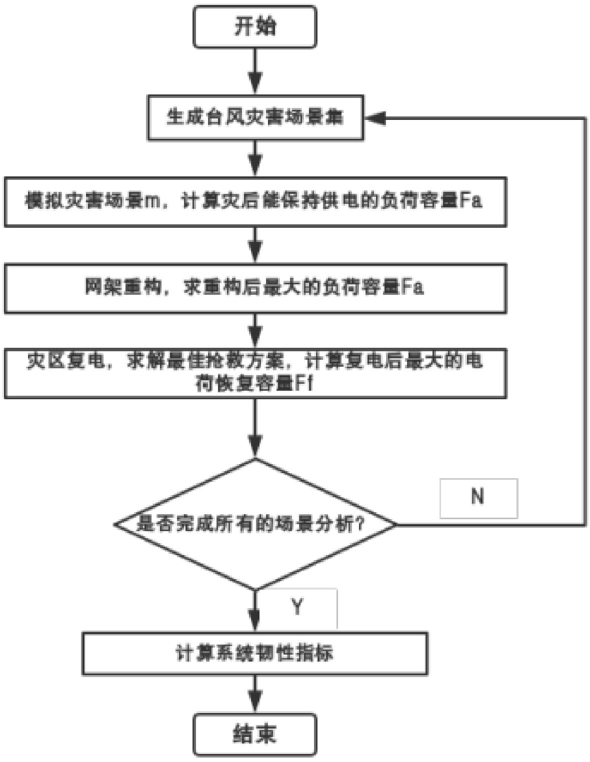

Figure 2 Evaluation model of typhoon resilience of distribution network

5. Summary

The economy influences the development of cities, and cities play an increasingly important role in modern life. The introduction of resilience provides a new paradigm and a new framework for urban lifeline system to enable cities to have greater space and capacity to cope with disasters.

To strengthen urban lifeline toughness, on city planning, the structure and function of the city should consider its integrity and complexity, enhance the urban lifeline systems work independence in order to reduce the overall damage caused by local damage phenomenon, at the same time also need to enhance the relevance of each system, cost-leadership strategy construction of lifeline system and auxiliary system, a subsystem collapse of other systems have the ability to quickly bypass the system continues to run, at the same time can use its resources to repair the damaged area and the design of the city must have the ability to resist disasters, can adapt to the extreme and has a quick rebound in and disasters affect robustness and flexibility; Urban construction and lifeline system update schedule keep consistent, regularly check the operation status of each system, and innovate the technology and management of lifeline system on the road of urban construction, ensure the lifeline system keep pace with urban development; The sustainable development direction should be firmly determined, and the city capacity should be constantly innovated to ensure the necessary green rate and idle land rate in order to enhance the disaster prevention capacity of the city. For the research of lifeline system resilience assessment method, relevant institutions and organizations can carry out practical operation on the basis of theoretical research, in order to seek the most accurate, most convenient and most direct assessment method to provide the actual resilience index for urban lifeline system.

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