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# The influence of “night” factors on urban earthquake disaster prevention

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**Abstract.** Existing urban planning and urban disaster prevention measures are mostly based on urban space and crowd behaviour patterns during the day, ignoring the anti-disaster demand for urban space at night. Since people's perception of urban space is quite different by night and daytime, with behaviours patterns varying much accordingly, thus the consequences of urban disasters occurring at night are more serious than those occurring during the day, including the trigger of secondary disasters, which are more harmful. This paper collects and analyses the data collected from the target location, and finds that the night factor has a certain degree of impact and change on urban disasters. Through the construction and improvement of disaster prevention lighting facilities, it can guarantee the normal function of evacuation and avoidance paths and areas at night to a certain extent, and help the affected people to carry out effective self-rescue and mutual rescue at night, thereby reducing the impact of disasters and protecting the lives of personnel.

## 1. Night and disaster

### 1.1. Disaster that occurred at night

The disasters which occurred at night have the following characteristics for urban disaster prevention:

*1.1.1. Sudden and concealed.* Affecting by changes in the gravitational pull of the earth, earthquakes happens mostly after 19:00 in the sunset to 6:00 on the next day, compared to the number of earthquakes that occur during the day [1]. This article uses Google search to conduct statistics on important earthquake information published in the world from January to December 2018. The results can be found that in the whole year of 2018, there were 236 earthquakes with magnitude 5 or above in the world, of which 108 occurred after 7 pm and 97 times after 10 pm.

*1.1.2. Increase the difficulty of rescue.* During the night, the city functions into a dormant state. If a disaster occurs, city management agencies will not be able to function in a short time like during the day. If the disaster level is high, damage to the city lifeline system will result in secondary disasters such as power outages and explosions, which will result in disaster prevention and disasters, and bring



about the consequences of casualties and property losses far higher than during the day [2][3]. At the same time, it will cause the expansion of disaster effects and the frequent occurrence of secondary disasters.

*1.1.3. Reduce risk aversion.* The main content of disasters at night is risk aversion and escape. In order to carry out these activities effectively, it is necessary to transmit information of the external environment to the brain through the senses, and the brain interprets the information [3]. In the evening, due to the limited visual conditions of the lighting conditions, the physical environment of the city has been destroyed by disasters, and people cannot effectively obtain relevant information, which limits the safe-haven activities.

The consequences of disasters at night are often more serious than during the day. The reason for this is mainly due to the following: 1) Reduced emergency response capacity. After a deep night's sleep, the functions of the body's senses are suppressed, and the response to external changes is slow. This leads to a longer perception of disasters, and it is difficult to make accurate and quick judgments on the senses in the process of hedging, increasing the probability of accidents. 2) Increased risk of safe haven escape. The urban space during the disaster will cause a large number of escape obstacles due to damage. Visual obstacles caused by darkness will reduce the speed of escape, prolong the escape time, and increase the difficulty of avoiding danger. 3) Activated insecurity. Damage to the urban lighting system leads to darkness, which leads to the loss of reason, confusion, trampling, and standing in the wrong place. Even misunderstanding of the original cognitive map caused by short-term memory ; These will interfere with people making correct risk escape judgments in times of crisis [5]. 4) Induced secondary disaster. These secondary disasters are often caused by lack of illumination, no guidance, emergency command, etc. in the process of risk aversion, which leads to people's lack of access to environmental information in the dark. 5) Reduced evacuation space usage [6]. After the disaster at night, most people gather in areas with lighting conditions to avoid danger, but the shrinking of lighting conditions causes the use area of the refuge site to be reduced and the use efficiency of the refuge space is reduced [7].

### *1.2. Night after the disaster*

The night after the disaster mainly refers to the follow-up night time after the disaster occurred during the day, and the rescue of the personnel and the development of the refuge life are all in this period.

*1.2.1. Expanding after the disaster.* When a disaster occurs, people must quickly leave the dangerous place and take refuge in a safe place because of the destruction of the house [8]. After a short period of refuge, the victims will concentrate on the basic daily life in the regular shelter, and use this as a base to carry out post-disaster reconstruction activities until the construction of temporary settlements is completed [9]. Night refuge life often has health problems and security problems due to lack of adequate lighting.

*1.2.2. Carrying on the rescue work.* The self-sustainment and rehabilitation of urban bodies in the face of disasters, that is, people's spontaneous rescue and emergency response is the self-organization phenomenon of urban bodies in emergencies, but nights limit people's disaster activities and restrict disaster relief, which is an important cause of serious consequences of disasters [10]. Taking the Wenchuan earthquake as an example. During the rescue vacuum period that the external rescue has not yet reached, the limited self-rescue of the local residents was interrupted by the coming night, thus losing the most precious life rescue opportunity [11]. After the external rescue arrives, the disaster relief work at night is also obviously subject to the visual environment and is in a state of stagnation, resulting in the effectiveness of rescue work not able to be fully exerted [12].

## **2. Night disaster prevention needs**

From October to December 2018, the project conducted surveys on the assumed earthquakes in the three types of areas from 22:00 to 5:00 in the evening. (Tianjin – a municipality with a major earthquake history, Luoyang – a prefecture-level city with a slight earthquake history, Wenchuan County – a small town in the 5.12 earthquake-stricken area) This paper obtains people's subjective judgments on nighttime city disaster prevention and safety from the questionnaire survey of four different factors, such as nocturnal habits, risk aversion, space identification, and psychological behavior. The questionnaire was designed and calculated in strict accordance with the relevant requirements of social surveys; 300 copies were distributed and 278 were returned. The following is the relevant law content summarized after the statistics of the questionnaire.

### 2.1. Nocturnal activity habits

This survey is mainly aimed at people's activities and different time periods at night to determine the physical conditions and responsiveness of people in the disaster. The results of the survey as shown in Table 1.

**Table 1.** Features and implications of nocturnal activities.

	Features	Implications
1	During the period from 18:00 to 22:00, the activities are relatively diversified, with home life, rest and relaxation, and a certain proportion of nightlife and work activities.	At night, people's activity space is mainly cantered on the living environment, but the proportion of modern nightlife is gradually increasing. Therefore, the key research areas for night-time disaster prevention are residential space and urban space including nightlife.
2	After 22:00, the activities are relatively simple, mostly rest and sleep.	The human body's ability to respond to external stimuli at different times is different. Improving people's ability to respond to disasters in the middle of the night is the focus of night-time disaster prevention.
3	Most people's physical condition can respond quickly to sudden disasters before 22:00, but after 22:00 this ratio will be reversed before.	People's night-time activities are more diverse, which is defined by the content of night activities.

### 2.2. Escape and hedging needs

The main content of this item is to investigate the risk-averse needs and psychological expectations of people in the event of sudden disasters at night, in order to preliminarily determine the main components of the safety of people in the event of disasters. After statistics, residents' escape and danger during the night's sudden earthquake have the following characteristics, as shown in Table 2.

**Table 2.** Features and implications of escape hedging needs.

	Features	Implications
1	The place to avoid safe escape at night is the place with good lighting conditions, followed by places with lots of people and flat and open places.	In the survey of escape and hazard demand, people pay more attention to the dark environment caused by a power interruption and have a higher demand for facilities that can provide suitable lighting in their environment.
2	The most worrying thing is that it is difficult to identify the escape route, congestion, separation from loved ones and accidental injuries due to darkness. It is expected that there are good lighting facilities, indicator	The main reason for fear of overcrowding is the disorder and confusion caused by crowding. If there is a way to alleviate this confusion and disorder, it can ensure safe haven in densely populated areas.

	signs and guard rails in the process of hedging.	
<b>3</b>	The density of the night crowd is directly related to the difficulty of avoiding risks.	People are willing to go to a safe place to avoid danger, and night-time disaster prevention design should consider this demand.
<b>4</b>	Willing to hedge in an area close to you.	

### 2.3. *Spatial identification needs*

This item is mainly to investigate the identification of the safe haven space by people at night as shown in Table 3, in order to preliminarily determine the main components of the space guarantee to ensure space identification.

**Table 3.** Features and implications of spatial identification needs.

	Features	Implications
<b>1</b>	Most residents want safe haven in good space.	The help of lighting mainly meets the visual needs of the residents at the time of the disaster.
<b>2</b>	People want to hedge their own familiar space.	The scale of the space should be wide enough; at least it should be designed to create such a feeling.
<b>3</b>	People are more willing to hedge in an environment with high color brightness.	The colour of space affects people's perception of the size and shape of space and affects people's safe-haven choices.
<b>4</b>	People are more inclined to hedge in places with large protection areas.	

### 2.4. *Psychological safety needs*

The main content of this item is to investigate the psychological needs of people during the risk-avoiding process at night as shown in Table 4, to preliminarily determine the main psychological components of ensuring safety during disasters.

**Table 4.** Features and implications of psychological safety needs.

	Features	Implications
<b>1</b>	Severe swaying, darkness, and loud noise can create a strong sense of insecurity in human psychology.	Proper lighting can alleviate psychological stress.
<b>2</b>	The darkness and crowding in the process of risk aversion will cause people's nervousness.	
<b>3</b>	Communication and comfort between acquaintances and a better visual environment can reduce people's bad psychological emotions during the risk aversion process.	Ensuring people's desire to find loved ones and enhance their survival.

## 3. **The role of lighting in disasters**

It can be seen from the above survey results that it is necessary to eliminate the effect of night dark environment on the amplification and enhancement of hazard factors, in order to improve the safety of nighttime urban space disaster prevention. The core role of disaster lighting is reflected in the following aspects

### 3.1. *Increase space identifiable*

Improving the identifiable of urban space at night through urban lighting is an effective way to ensure the safe evacuation efficiency and reduce the casualty rate. Improve the identifiable of urban space in the following aspects as shown in Table 5.

**Table 5.** Ways to improve the night-time recognisability of urban space.

Contents	
<b>1</b>	Enhance the night-time illumination of iconic monolithic buildings, ensuring directional guidance and area identification throughout the area through the night-time recognizable of such buildings.
<b>2</b>	Ensure the road lighting during the disaster, and provide the disaster prevention path for the night disaster through the directivity and continuity of the road.
<b>3</b>	Through the unified interface on the light colour, the identification of the direction of the night-time at the time of the disaster and the choice of the escape route are enhanced.
<b>4</b>	Improve the recognizable of night city signs, which is another important clue to find directions at night, and can be an important platform for information release.
<b>5</b>	Bright and orderly accent lighting in the area to reduce adverse psychological effects and malignant events.
<b>6</b>	Improve the visibility of the node space such as plaza at night, meet the requirements of safe-haven activities; ensure the pivotal role of node space in the overall spatial structure.

### 3.2. *Safeguarding safety*

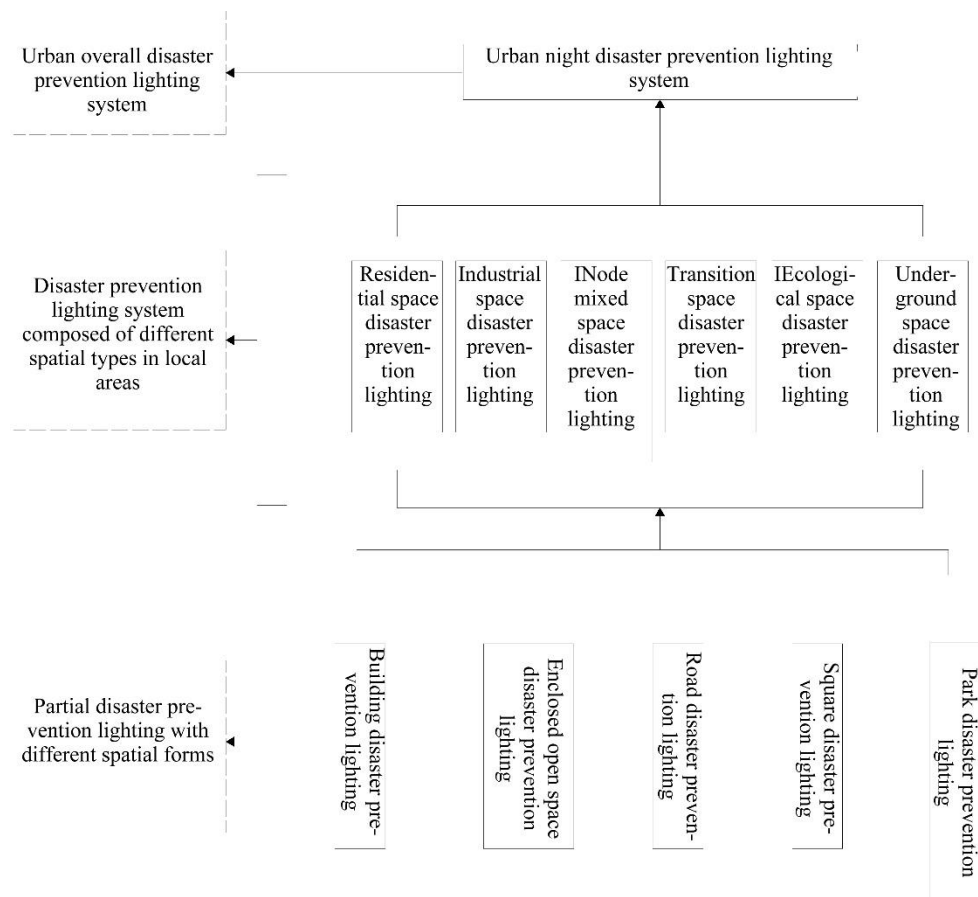
The illumination of the environment during nighttime disasters directly affects the quality of visual reception of information, which in turn affects the safe behavior of people in disaster-causing environments. Under poor lighting conditions, people are prone to struggles between motivation and correct identification, causing people to hesitate and slow to respond the dark environment is also prone to human illusions, making false judgments and behaviors leading to unintended consequences.

### 3.3. *Maintain positive psychological impact*

Lighting will have different effects on refuge life. Poor lighting conditions make people difficult to identify, which can lead to frustration. The longer the duration, the more frustration will increase. In addition, the difficulty of identification can make people become unconfident. Visual fatigue and general fatigue can have a negative impact on people's emotions. On the contrary, the bright light environment makes people feel open and happy; contrast and shadow also affect people's emotions, moderate contrast, less shadow interference will make people feel relaxed and happy. This has important guiding significance for the refuge life after the disaster.

## 4. **Structural framework of night-time disaster prevention lighting system**

As a system covering the city, disaster prevention lighting is produced by a reasonable organization of lighting systems of different levels. This hierarchical relationship can ensure the effective coverage of the night-time functional area of the city by the disaster prevention lighting, and at the same time ensure that the system is organically integrated with other systems such as urban space and urban lifeline. In this paper, the disaster prevention lighting is divided into three levels, namely: the macroscopic overall urban level, the mesoscopic local regional level and the microscopic single spatial level, as shown in Figure 1.



**Figure 1.** Disaster prevention lighting structure level. (Source: Author drawing)

## 5. Summary

This paper mainly studies the relationship and interaction between "night" and "urban disaster". By analyzing the relationship between "night disaster" and "disaster night", the different functional requirements of nighttime disaster prevention in urban space are proposed. On this basis, the characteristics of nighttime disasters were analyzed, and the survey documents of different regions were statistically compiled. The feedback information of residents was summarized from different aspects such as nocturnal habits, escape risk avoidance requirements, space identification needs and psychological security requirements. Combining the relationship and characteristics of nighttime and disasters, the important role of disaster lighting is proposed. By establishing a night-time urban disaster prevention system based on lighting, it will be able to effectively ensure the safety of nighttime urban space disasters, alleviate the safety pressure caused by disasters on urban material space damage, reduce the occurrence of secondary disasters, and improve disaster prevention and avoidance and disasters.

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