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ORIGINAL ARTICLE

The Campus of University Earthquake Disaster Prevention Planning

- The Research of Spatial Pattern Based on GIS

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Abstract

In the background of rapid urbanization and frequent earthquakes, earthquake disaster prevention planning has become an important topic of current research. Universities are irreplaceable disaster shelter, as they are public institutions with a lot of open space. This article puts forward the concept of "disaster prevention campus". With the refuge behavioral and psychological characteristics of people in the campus when the earthquake happens, it integrated uses GIS spatial analysis technique, takes Shandong Agricultural University as an example, and studies the spatial pattern of earthquake disaster prevention planning in campus from five aspects. The aspects include building distribution, population distribution, analysis of service radius, infrastructure configuration and choice of the optimal refuge path. On the basis of researches above, reform proposals and specific strategies are put forward to build the safe and harmonious disaster prevention campus.

Key words : Disaster prevention campus, Earthquake disaster prevention planning, GIS, Refuge behavioral and psychological

1. Introduction

With the rapidly developing economy and society and deteriorating ecological environment, the earthquakes, fires, typhoons, mudslides and other disasters occur frequently, which caused significant damage to the development of people's lives and property safety, economy and society . Earthquake disaster prevention has become a task that can not be ignored(Shen and Qi, 2007).

Universities as a national repository of talents, which is the forefront of the social disaster prevention and mitigation. They have plenty of open space and relatively good infrastructure(Li and Wang, 2009). They are irreplaceable disaster prevention shelter. Therefore, this study put disaster evacuation plan into campus design, putting forward the concept of "disaster campus", that is, except the basic functions with a common campus, but also has the function of campus disaster prevention. This can

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not only provide disasters settlements for teachers and students, but also providing disaster evacuation sites for residents of surrounding communities, and even playing an important role in process of disaster prevention and evacuation of entire cities.

In this paper, we analyzed spatial pattern of campus disaster prevention plan with GIS technology, combining the investigations of refuge behavioral and psychological in campus, in-depth studying of the actual situation and existing problems of campus disaster planning, mading proposals and strategies for planning reform which provide a scientific basis for disaster planning construction of university campus.

2. Research Methods

2.1. Survey methods

We select the north campus of Shandong Agricultural University and the new campus of Taishan Medical College for the survey sites, using questionnaire to visit school students, school staff and the surrounding community and learning about their various refuge behavioral and psychological in the earthquake of campus, analyzing selection trends and influencing factors on evacuation routes and site of people, providing a reliable reference and scientific basis for the planning and design of future evacuation routes and sites.

Fieldworking campus building distribution, population distribution, the distribution of the road system and the status of refuge sites and related settings of refuge facilities, and recording in the form of text and charts.

2.2. analytical methods

GIS (geographic information system) is a analysis and management information system of spatial objects based on a database management system (DBMS), which is a important tool for disaster information acquisition, processing and integration of diverse information. It has obtained important application in emergency setting evacuation planning (Ye et al., 2010).

In the present study, we analysed the spatial pattern of campus disaster planning used GIS technology. First, extracting and ranking the buildings, population, evacuation facilities, evacuation sites and other information of research area used the Auto CAD software. Secondly, under ArcGIS 10.0 platform, the source data is converted to produce feature layers (shape format), and edit the properties of the elements, formating different levels of color distribution. Again, we use multi-function ring buffer of ArcToolbox neighborhood analysis, analying the different services radius and displaying coverage area of refuge sites of the university campus; through the overlay function of analysis tool, overlying the choice of refuge venue and infrastructure distribution maps, then obtaining infrastructure distribution maps of each refuge venue. Finally, adopting the Network Analysis tools of ArcToolbox for topological editing, building road network system, realizing the choice of the optimal evacuation route. Specific research steps and analysis process shown in block diagram (Fig. 1).

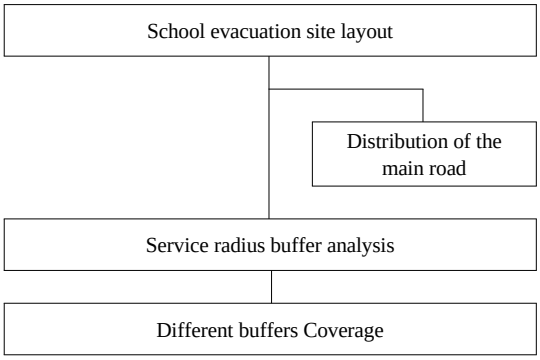

Fig.1. Research procedure and analysis flow chart.

3. Results and Discussion

3.1. Refuge behavioral and psychological research in campus

As a general behavior to protect themselves when a major disaster occurs, the refuge is a human instinct. Although different types of disasters, and the occurrence of situations vary widely, but some staff of psychological research shows that people's behavior and psychology activity in a disaster tend to follow a certain pattern, and this pattern is the same in many disasters, which provide a scientific basis for disaster planning(Liu, 2011).

Since this study was carried out on college campuses that are particular place, the main target of investigation from the following three categories: school students, school staff and school faculty residents of the surrounding community. The students and faculty staff are trained in higher education generally, having a higher cultural level, whose cognitive and judgment abilities generally higher than the average person. Thus, their refuge behavioral and psychological have some differences with general population, so the targeted research is needed for them.

3.1.1. behavioral and psychological when selecting evacuation routes

Through questionnaires and interviews for different groups on campus, we discovered that people choose the different path of refuge when an earthquake occurs, After the survey, we get the following results(Fig. 2).

As shown, in the emergency evacuation process when taking place the earthquake, people choose different paths of the refuge. 37.92% of the people choose safe evacuation route, which reflects the characteristics of people instinctively avoiding disadvantages. 22.32% of people choose bright path, reflecting the people's phototropic psychologyl. So we should pay special attention to the lighting facilities in the design. 18.96% of people choose the familiar path, which help people cognize surrounding environment clearly to make more appropriate accurate refuge judgment. 13.15% of people choose the nearest path, which reflects the psychology that people want a quick escape. 7.34% of people choose to follow the majority. The main reason is that at the time of the earthquake broke out, people would be the height of panic and anxiety, poor judgment. Then herd mentality will appear. People followed the most people blindly, which is likely to cause congestion and lead to mass injuries.

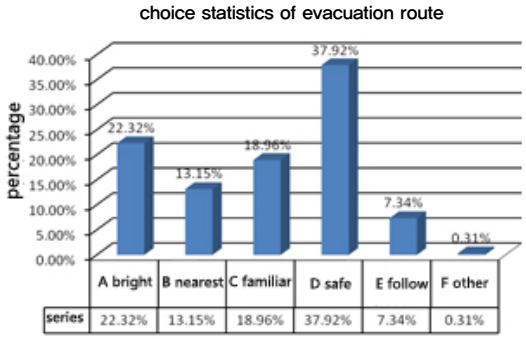

Fig.2. Choice statistics of evacuation route.

Though analying the choice of the evacuation route of people above, the accurate, clear, and easy escape routes is most needed for people in the chaos and stress state of the disaster. Also, in order to divide the different levels of exports and refuge roads, we should do the survey analysis before design, making precise statistics to the use of surrounding roads of the site and population density and circadian activity rhythm changes. Thus, people can escape safely, quickly, accurately in the disaster.

3.1.2. Behavioral and psychological during selecting the evacuation site

3.1.2.1. refuge site selection

As shown in the statistics for asylum site selection (Fig. 3): people choose internal space as a major

disaster evacuation sites(accounting for 68.11% overall selection), which reflects the campus space plays a particularly important role in the evacuation process. Secondly, accounting for 26.69% of people choose the stadium, flat open, large area. it is also an important venue for asylum. In addition, the percent of people who select halls or sports centers, and the proportion of outside space left in the building are relatively low (hall or activity centers accounted for 3.06%, accounting for 1.53% of open space outside, stay in the construction accounted for 0.61%), and its refuge function is weak, only a small portion of people will choose to take refuge in these venues.

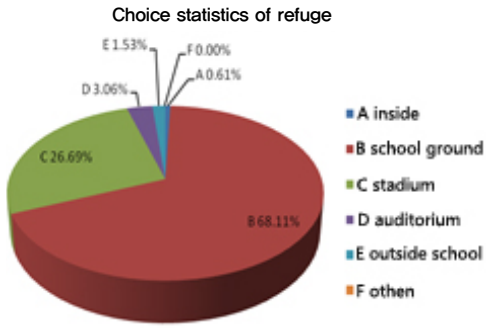

Fig.3. Choice statistics of refuge.

In the survey population, students accounted for 76.36% of the total survey, faculty accounted for 16.26% of the total population, school staff accounted for 7.38%. Visible, students will still be the main refuge in schools, and in terms of the proportion of staff from outside, indicating college campus has assumed certain social refuge function and plays a role in the city's asylum system.

3.1.2.2. Factors to consider when selecting refuge venue

Different people choose different considerations on refuge venue, the survey shows (Fig. 4): 32.83% of the people choose the short distance evacuation sites, which indicates that the distance is an important factor in selecting the site of refuge. The refuge venue can be reached in a short time is the first choice for people. Secondly, the flat, well-equipped but also the main factors to consider when people choose venue (choosing flat accounted for 19.36%, selecting facilities accounted 16.84%). In addition, bright and spacious (representing 11.78%), easy contact with the outside world (representing 10.44%), more familiar (accounting for 8.75%) is a factor when people choose to evacuate the venue followed by consideration.

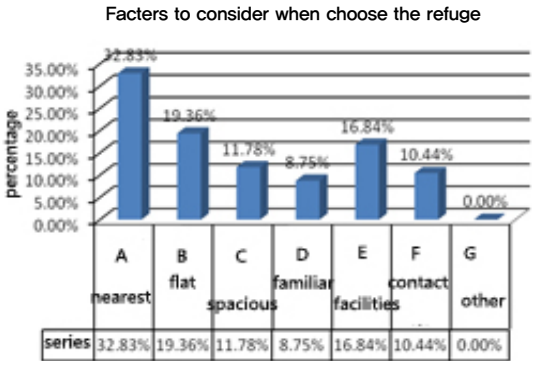

Fig.4. Factors to consider when choose the refuge.

From the analysis that the factors people consider when choose evacuation sites, we know that the refuge venue should close to people's daily activities in the area first. So you can get to a safe zone in a relatively short period of time. Secondly, requiring evacuation site itself has some corresponding properties, such as flat, fully equipped, bright and spacious, easily contact with the outside world and other characteristics. These can be emphasized by the design of the site itself. For example, by ground pavement pattern, color changes, strengthening the distinction between venues, combined with hedges and other plant materials divided various camping sites and medical.

Through the above investigation and analysis of choice of evacuation routes and evacuation site of school crowd, we know that people's psychological

behavior is different from ordinary in the event of a disaster, and has certain characteristics. Therefore, in future disaster planning and design, in addition to meeting the technical requirements of the general sense, but also should pay particular attention to the special psychological and behavioral characteristics of the people in the disaster, to meet the real needs of people when disaster thus maximize playing the role of disaster campus, providing a reliable reference and scientific basis for integral post-disaster planning research of campus.

3.2. Case study based on GIS technology

Shandong Agricultural University is located at the foot of magnificent Taishan which is located in the center of Taishan District of Tai'an city. It next to the east culture road north and along with the Daizong Street south, on the west side of the Longtan Road, east of Nai river. The campus covers an area of 1066 acres, building area of 930000 square metres, green rate of 40%. The topography of the east is low and the west is high, flat terrain.

Old campus and high density of the population exist a hidden dangers from the perspective of disaster. In order to cope with all kinds of unexpected disasters, the further research and improvement of its campus disaster planning is needed. Therefore, Shandong Agricultural University, North Campus, for example, we used GIS technology to analy specifically for its spatial pattern. In addition, because the east side of the campus(specifically part of the Water Conservancy Vocational School) is under construction, thus be removed from the scope of this study.

3.2.1. Distribution of school buildings

We conducted the status of school buildings though on-the-spot investigation and statistics, according to the different floors, the use of the feature attribute editing function of GIS generates different color layers (Fig. 5). The deeper the color, which means that the higher building layers. The higher the building, the greater the risk factor when the earthquake disaster. The figure shows the east side of the campus area is mainly faculty's office area. The buildings are mostly four layers or five layers, and a large floor space, so the hazard is small in earthquake. West of the main campus area is the student's living area, and the buildings are mainly layer 4 and below, so the risk is small. The Liberal arts building on the north side of school has the deepest color with layers of 12, which is the tallest building on campus so far, existing a big danger in the earthquake. According to the buildings distribution status of school, we should control the height of buildings in proper and strengthen the design of earthquake disaster prevention of buildings, improving the seismic coefficient of the buildings, which plays a particularly important role in the "Disaster Prevention Campus" plan.

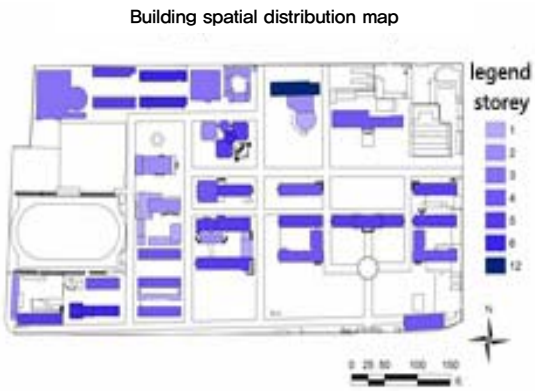

Fig.5. Building spatial distribution map.

3.2.2. Distribution of the population of school

As the school population distribution is more dispersive outdoor, and generally active, so is also easier to escape during disasters. So, we only discuss the distribution of the population inside the building here. Through on-the-spot investigation and statistics for population of the buildings, the most population number of each building, and the use of the feature

attribute editing function of GIS to generate the number of different colors represent (Fig. 6).

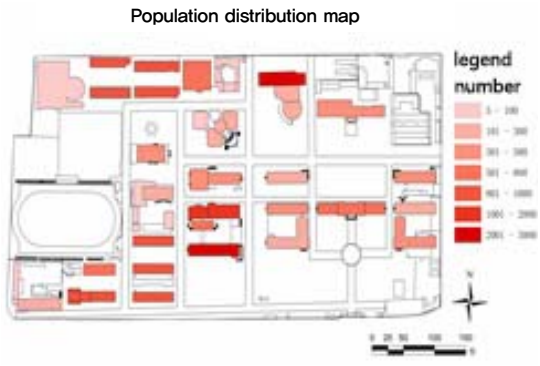

Fig.6. Population spatial distribution map.

As shown, the darker the color, the greater the population density, the greater difficulty to flee the building during an earthquake. The population of office space is less in east side of the campus. The congestion is relatively low during an earthquake. The main buildings of the living area on the west side are the student dormitory, within which have a larger number of the population, fleding difficulty is relatively large when the earthquake. The crimson teaching area lie in central section of campus, with the largest population density of classroom building, the highest level of congestion, and the biggest danger during an earthquake. In addition, the population of Liberal arts building is greater, due to higher floors, the relative congestion level is less than the teaching building. But due to high floors of people flee uncomfortably and slower, also has a certain degree of risk. Though the current situation of population distribution on campus, we should strengthen refuge evacuation and entrances design inside the building, so as to allow people to escape the building quickly and reach a safe area.

3.2.3. Evacuation site distribution and service radius analysis in school

As shown(Fig. 7), the dark green portion is the evacuation space. The more and larger refuge area on east and west region in campus is relatively large. In the middle area of the campus, the venue is less refuge, the area is not large, and the building is more concentrated, can not better meet the needs of asylum.

Evacuation site service radius is determined according to the size of the venue. The venue of different sizes have different service radius. Since the study area within the refuge for the college campus venues, so the service radius is much smaller than the radius of the disaster service in parks. According to the green scale and distribution patterns in north campus of Shandong Agricultural University, respectively, 100 m, 80 m, 50 m radius for the service, using Multiple Ring Buffer of neighborhood analysis in ArcToolbox namely polycyclic buffer function (Ferdimando,1996), doing buffer analysis to refuge venues on campus, getting different buffer coverage (Fig. 7).

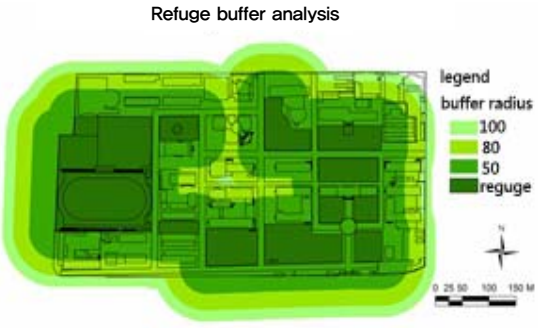

Fig.7. Refuge distribution and buffer analysis diagram.

We can obtain from the diagram that 50 m service radius buffer zone only to meet the needs of evacuation of parts in the campus. The central region and the dormitory on northwest side of the campus can not be overridden, and the population density in these areas is relatively large, so in terms of the service radius of 50 m, there is a certain service blind spot. 80 m service radius buffer zone meet the basic

needs of the entire campus evacuation. 100 m service radius buffer zone not only to meet the needs of the entire campus evacuation, but also provide a venue to evacuate the disaster for surrounding community residents. The analysis of refuge buffer space is conducive to understand the scope of services with different radius of the campus, allowing rational planning the spatial distribution of refuge sites in "Disaster Prevention Campus" .

3.2.4. Choice of refuge venue and distribution of infrastructure

Through GIS analysis tool composition function, stacking the refuge site selection and infrastructure distribution to obtain the distribution map of perimeter of each refuge venue facility (Fig. 8).

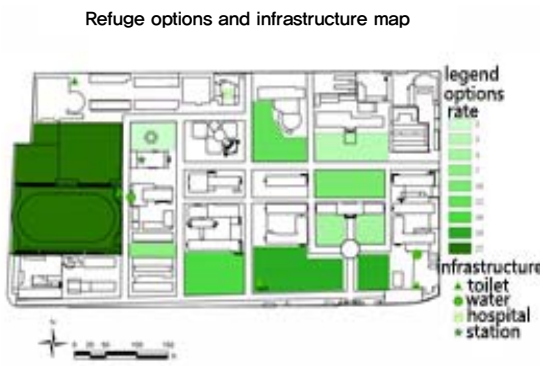

Fig.8. Refuge options and infrastructure distribution map.

In the figure, the darker colour of refuge areas means that the higher ratio of choosing them as refuge sites. Among them, the stadium is the highest rate of asylum venue for people. It is not only flat, open, large area, surrounded toilet, boiling water room, radio stations, etc. infrastructure, but also adjacent to the city's main road, Longtan Road, contacting with the outside world easily. Next, the ratio is larger people choose the south gate entrance green, mainly due to the large size, no tall buildings around, and connected with the city roads Daizong Street, easily contact with the outside world. It addition to providing refuge outside the venue for the teachers and students, but also providing some refuge space for the surrounding community. In addition, the other refuge venue mainly services for the crowd within the around buildings, area and service radius is relatively smaller, with a certain relevance.

The figure shows that the infrastructure distribution within this campus is less and uneven, lacking of specialized disaster prevention facilities. In the future, it should be improved within transformation to strengthen the refuge design of related facilities.

3.2.5. Distribution of major roads in school and the optimal evacuation path analysis

Within this campus roads distributed into the net, divided into one, two, three sevels, and its width was more than 6 meters, 3 meters to 6 meters, 3 meters or less. After the earthquake, during the evacuation, people need mostly is to choose the best path to quickly reach the evacuation site, out of danger. Stadium as the largest and most suitable refuge sites in campus, needing to bear populations from different regions in schools. Thus, in the figure(Fig. 9) we select the crowd of A, B, C three buildings fled to the stadium, for example, to analyze the shortest path.

Fig.9. Optimal evacuation path analysia diagram.

In ArcMAP environment, the use of GIS Network Analysis tool that is to say network analysis, topology editor, building a road network system (the default is the existing road network of the campus),

which is preferable to shortest network distance from each building to the stadium, so that people can reach the stadium and quickly out of danger within the shortest possible time. The choice and planning of the best evacuation route and evacuation roads have an important role in post-earthquake evacuation and rescue operations, directly impacting on the effectiveness of the evacuation and rescue.

3.2.6. Suggestions for improvement

Through the above study and analysis using ArcGIS technology to spatial pattern distribution of buildings, population, asylum venues, infrastructure, roads and so on in the north campus of Shandong Agricultural University(Yu et al., 2001). We know that, the master plan of this campus can better meet the disaster prevention needs of the crowds in campus, with a certain degree of disaster prevention function. But there are still some problems in some specific planning and design. In order to better meet people's refuge needs and improve the overall earthquake disaster prevention capability of campus, making the following recommendations for the problems:

(1) In the central area of the campus, exieting more intensive building, but relatively few asylum grounds, with smaller area, whith can not meet the needs of the people to refuge. Adding new asylum grounds is more difficult, but we can increase exports and evacuation channels around the building, broadening road width access to the stadium and other venues larger refuge, so that the evacuation population of this area dispersed to other venues, mitigating the burden of the refuge sites.

(2) Infrastructure evacuation design is less and uneven distribution in campus. To add a set of related infrastructure, particularly the construction of infrastructure around the larger evacuation, including the establishment of headwaters, fire protection system settings and outdoor toilets. In addition, under the principle design of "Combine Peace And Disaster", with a reasonable set of facilities with functions that can be converted. Meeting the needs of people in peacetime, but also be able to better meet people's resilience and disaster evacuation function and a variety of life needs after disasters.

(3) Fewer identification system with indicative role. In my interviews, many respondents even said that they are not clear the position of evacuation site in campus. First, we need to establish a unified identity indicating system, the use of eye-catching, accessible, continuous, uniform symbols and signs. Second, strengthening guiding devices of the intersection and asylum venue entrance to ensure its continuity and effectiveness from space level. Also, we should consider the identification systems indicative fuction in evening especially the case of power outage.

According to recommendations made above, which can help designers strengthen the design of disaster prevention aspects during campus planning, improving the existing deficiencies in disaster planning of campus, truly reaching the requirement of "Disaster Prevention Campus", thus maximize disaster evacuation function of the university campus when disaster occurs.

4. Conclusion

This paper presents a "Disaster Prevention Campus" concept, immersing the disaster prevention design into campus planning. Based on the investigation about special behavioral and psychological characteristics of people in the event of a disaster in campus, the use of GIS technology research it from building distribution, population distribution, the service radius of the evacuation site, setting of infrastructure, road systems and selection of the best evacuation route and other aspects, coming to relevant methods about the campus of

universities earthquakes disaster prevention planning and relevant conclusions of spatial pattern of campus. In the light of the existing problems, we propose specific reform proposals.

Through application examples, verifying the correctness of the choice of using GIS to study earthquake disaster prevention planning. It store and manage large amounts of data, graphics, providing an ideal platform for analysis, and combining the establishment of theoretical model, successfully realizing the research of the earthquake disaster prevention planning. But how to take advantage of powerful data analysis and simulation capabilities of GIS to create a more scientific and more practical disaster planning system also needs further study. I believe GIS application will be more broad in the earthquake disaster prevention planning .

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