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A graded pedestrian flow early warning for an ancient street

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Abstract

To keep an ancient street to be safer, the pedestrian flow in an ancient street is observed and a graded pedestrian flow early warning is constructed based on the "Guidelines for evaluating carry capacity of scenic area", the actual monitoring and some primary research productions.

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Keywords: pedestrian flow, a graded early warning, instantaneous carry capacity

Nomenclature

C_1	instantaneous carry capacity of scenic area
X	the effective area to visit (m^2)
Y	per capita area to visit (m^2 /p)
Subscripts	
i	the scenic spot
j	the facility

1. Introduction

Recent years, people often assemble to form the dense crowd for political and regional activities, big events, festival celebrations or natural disasters etc. As the population distribution has become increasingly concentrated, this phenomenon is more and more obvious. However, stampede accidents frequent in large-scale crowded people owing to absence of effective management and control, which results in serious casualties [1]. According to incomplete statistics, during 2000 to 2010, the number of key stampede accidents totaled more than twice as many as that during 1990 to 1999.

China together with Saudi Arabia and South Africa top the high incidence of stampede accidents, following India. The situation of these accidents is not going well. On January 1, 2015, a massive crowding and trampling occurred at the Chen Yi Square on Shanghai's Bund in Huangpu district. It resulted in 35 deaths and 43 injuries, which shocked people in the world [2]. After this event, relevant agencies in other hot scenic spots with crowded tourists in Shanghai paid high attention to it. Entrusted by a Shanghai ancient street, we size up its status quo of distribution of flowing people and evacuation capability, and put forward the corresponding suggestions and measures aiming at existing problems.

2. Profile of the ancient street

The block consists of an about 200-meter-long North Street and 160-metre-long South Street. These are two main streets less than 2.5 meter in width. A stone arch bridge connects these two streets, under which a river flows. The block picture is

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as follows. North Street boasts special foods and South Street, tourism souvenirs, antique, calligraphy and painting, all of which forms the bustling streets of leisure, tourism and shopping. There are about 2000 employees and residents. In addition, every day here attracts numerous tourists, no matter on weekdays or at weekends.

Usually, the time-honored structures along the streets are of woods and bricks. Obviously, fire separation is inadequate. What's more, the materials are flammable and the structures are vulnerable. The block itself has great risks. It is imaginable if fire occurs or other emergencies happen during rush time, people in panic would push each other in narrow streets, it would have grave consequences. Therefore, we recommend making regular round-inspection work in the ancient street, to ensure evacuation passageway unblocked and escape signs clearly exposed. Furthermore, we should set up a graded pedestrian flow early warning.

3. Field research

3.1. General Situation of crowd in the street

Treating South Street and North Street as the center, the evacuation routes as the branches, and the distribution of pedestrian flow is observated. It shows that crowd mainly focuses on South Street and North Street.

There are many stores for small goods along North Street. The shops areas are generally small, and they will not attract too much pedestrians to stop. There are no stores along the evacuation routes to the north, so some pedestrians would occasionally pass, but no one stop. There are two large restaurants and tea houses near the stone bridge in North Street, and that may result in a large crowd around midday.

South Street is shorter than North Street. Because there are many stores for snacks, tea houses and restaurants along the street, and sometimes even bicycles, three-wheeled vans pass through, so it is easy to form aggregation of pedestrians, as shown in following figures.

(a)  (b) 

Fig. 1. The phenomenon of congestion in South Street for (a) aggregation of pedestrians in the front of stores and (b) none-motor vehicles passing through

3.2. The actual monitoring of pedestrians

Take the supervisory video recording in the middle of North Street as an example, the pedestrian flow is analyzed. On some workday morning, we observe the pedestrian flow between 10:00 am to 13:00 pm, and calculate the density of pedestrians in the area marked by two red lines, see table 1.

According to the observation by monitor and the description of staff, the general situation of the pedestrian flow could be summarized as below. 11:00 am-15:00 pm is the rush hour of pedestrian flow. On workdays, in some parts of North Street the maximum density could reach 2.5 p/m^2, and may reach 3 p/m^2 for South Street. On weekends and holidays the street will be more crowded, and in some parts the density in rush hour may even reach 4.5 p/m^2.